MACHINE DESIGN

June 1953

PREDICTING CASTING COSTS

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MOTOR CONTROL
C-H

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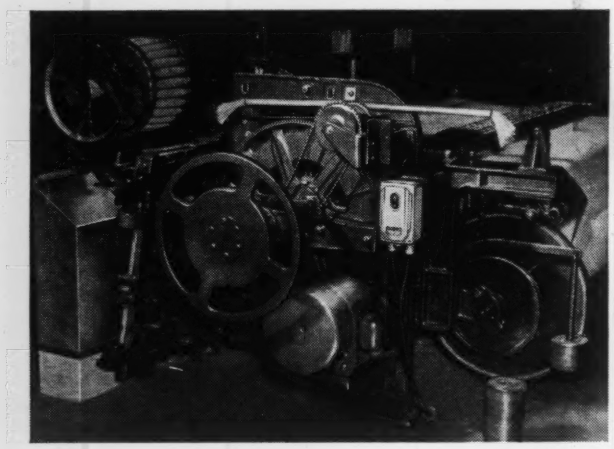
THE MARK OF BETTER MACHINES



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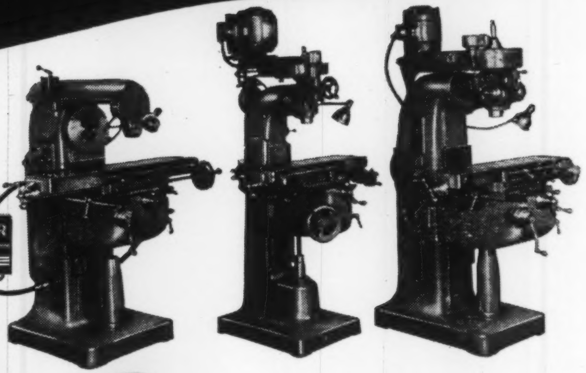

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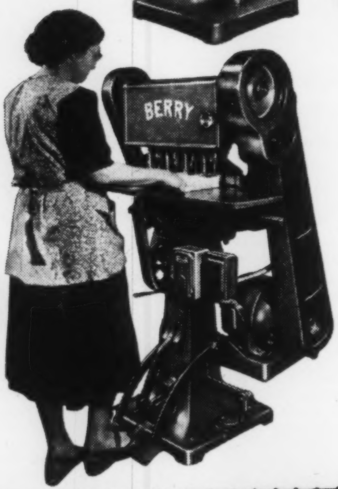

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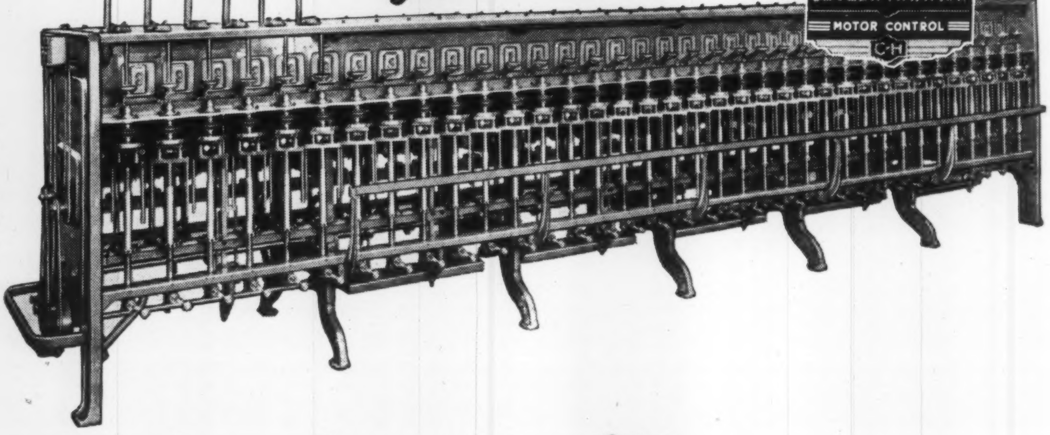

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FOR ENGINEERS AND DESIGNERS

MACHINE DESIGN

June, 1953
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Over the Board

When Will It Be Published?

One of the most frequent questions asked us by readers and authors is, how long does it take to plan and develop an issue of MACHINE DESIGN? In this brief trip behind the scenes we shall try to give you an idea of the time element in periodical publishing. The feature articles in the June issue which you are now reading were selected back in the middle part of February. At that time the articles were complete and in our hands ready for editing. Therefore the planning and writing of the individual articles dates back much farther.

Editing and the preparation of illustrations were completed by the end of April. By May 15 all engravings had been made, type had been set, and the pages had been made up in "dummy" form by pasting up proofs. The remaining three weeks until delivery have been employed in page makeup, proof reading, printing, binding, wrapping and mailing. News items and new part announcements, of course, are on a much faster schedule because of the essential element of timeliness. Additionally, changes may be made up to the time of actual printing in order to bring everything up to date.

This Month's Cover

"From the halls of Montezuma to the shores of Tripoli" engineers who can predict casting costs will, like the Marines, always have the situation well in hand. To illustrate Tripoli's article which begins on Page 139 Penton artist George Farnsworth has depicted on the front cover a high-quality aircraft casting with a graph in the background showing how casting costs increase with complexity in design.

MACHINE DESIGN

New Parts and Materials

Two and a half years ago we inaugurated a novel "data sheet" style in announcing new parts and materials. To insure completeness we often had to go back to manufacturers or their agencies for more information, which was sometimes forthcoming and sometimes not. We kept hoping that our efforts would strike responsive chords among manufacturers and result in more complete initial news releases or at least more prompt response to our requests for additional data.

Too often, however, publication of announcements has been delayed pending receipt of needed information, while incomplete items have been wasting space that could have been devoted to additional items.

Accordingly, beginning with this issue, we are replacing the data sheet form of presentation with a brief, capsule style which permits us to publish more items each month in the same space (Page 188). Additionally, the items will in general be more up to date. Those of you who need it can obtain more information direct from the manufacturer simply by circling the appropriate number on the postage-free card on Page 219 and mailing promptly. While we are on the subject of reply postcards, don't overlook the useful service provided by the card on Page 35.

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Published on the seventh of each month. Subscription in the United States and possessions, Canada, Cuba, Mexico, Central and South America: One year $10. Single copies, $1.00. Other countries one year, $15. Copyright 1953 by The Penton Publishing Company. Acceptance under Section 34.64 P. L. and R. authorized.

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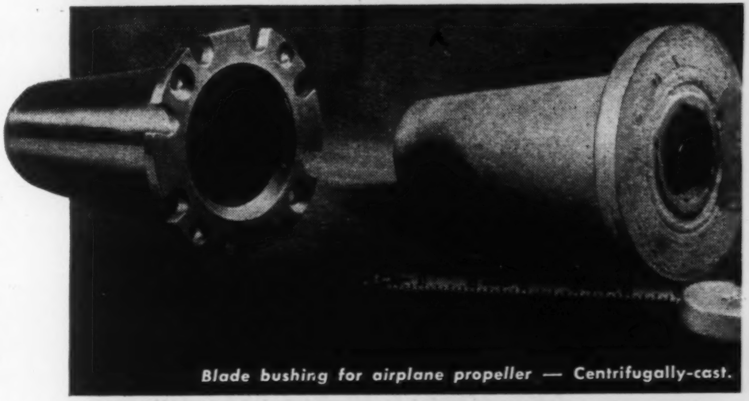

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MACHINE DESIGN Topics ... IN ENGINEERING AND RESEARCH

Tiny Bearings Ground at 100,000-rpm Speeds

Inner-race bores on miniature ball bearings are ground with small vitrified grinding wheels operating at speeds up to 100,000 rpm at Miniature Precision Bearings Inc. Special grinding machines or attachments have feed mechanisms graduated to 0.00001-inch, and bores are held to a 0.0001-inch tolerance. High-frequency wheel heads or pneumatically driven spinners are used to rotate the wheels at such high speeds on this and similar operations.

Electronic Shutter Permits Film Recording of TV

Film records can be made of both 525-line and 819-line TV pictures by use of an electronic shutter developed at the Naval Research Laboratory. The TV picture is synchronized with the film by a pulse generated in the motion-picture camera which operates the shutter. A "gamma control" modifies the picture to make best use of the film's exposure characteristics, and a video amplifier that gives flat (uniform) amplification from 30 cycles to 10 megacycles permits "high fidelity" picture reception.

Brittleness Eliminated in New Form of Polystyrene

A new polystyrene plastic film, "Styroflex," doesn't exhibit any of the brittle characteristics of other forms of polystyrene, according to the Natvar Corp. The flexible oriented film, having the same good electrical properties as its parent material, is primarily designed for high-frequency insulation. Having a softening point of 95 C, the material has high compressive and tensile strength, and is nonhygroscopic.

Pay Higher in Business than Government

White-collar federal salaries up to the $3800 level are equal to or exceed similar salaries in industry, according to Jerome M. Rosow, former director, policy division of the Office of Salary Stabilization. But "as the levels of responsibility and knowledge increase, the gap between government and industry tends to widen rapidly." Only 300 federal officials earn more than $15,000 a year, "almost an entrance salary for executives in industry." Since 1939, average weekly earnings of manufacturing employees have risen 180 per cent; maximum salary for the highest federal career grade has advanced only 31 per cent.

Transparent Shatterproof Canopies Developed

Shatter-resistant even when struck by flak or direct gunfire, newly developed canopies for jet fighters have just completed laboratory tests. The transparent plastic hoods announced by Lockheed are laminated of two layers of Plexiglass with a soft vinyl core similar to that used in safety glass.

Pneudraulics—A New Science?

One of the novel but rather visionary ideas tossed off casually by *Brainstorms,* a publication of Reed Research Foundation, is the future possibility of a new science—Pneudraulics. Compressibility of air makes pneumatic energy accumulation possible, but this same compressibility

Bearing Performance Assured

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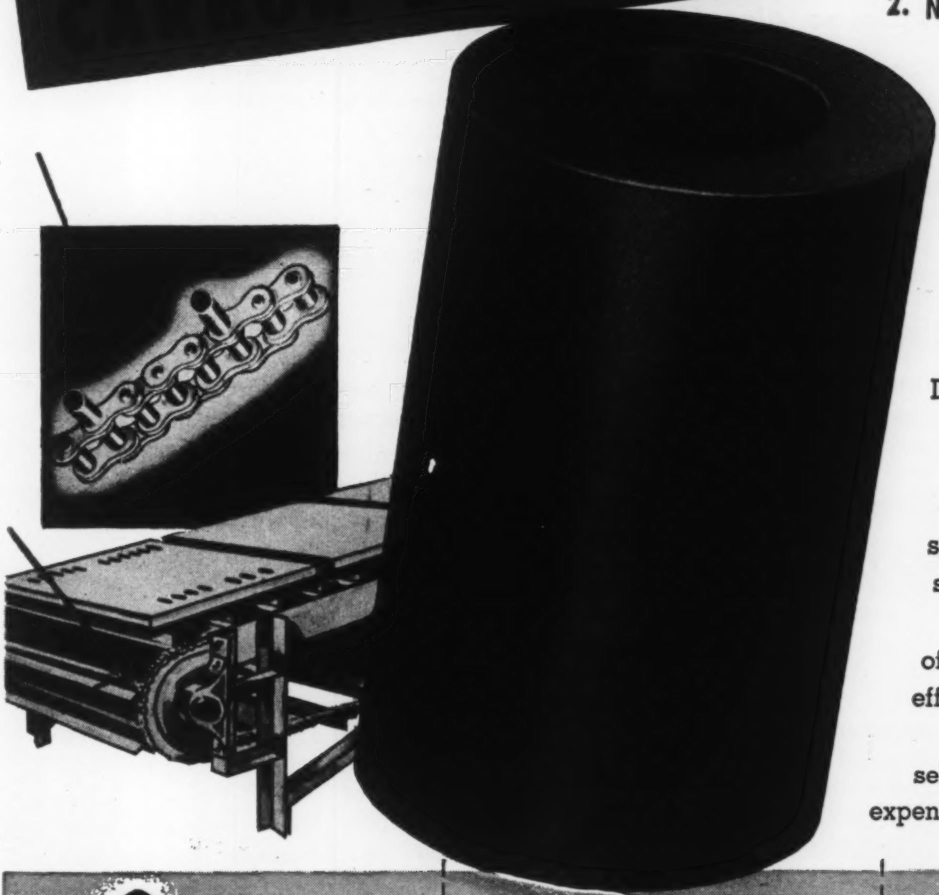

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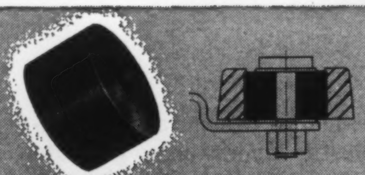

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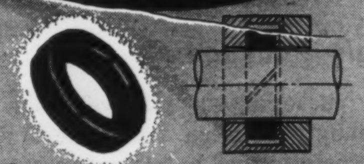

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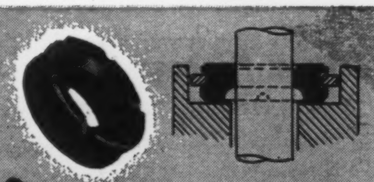

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prevents long-distance transmission. Hydraulic fluids, being comparatively incompressible, can be used for relatively long distances, but energy surges can propagate—and hydraulic-pneumatic auxiliaries are necessary to damp surges and provide energy accumulation. A unique approach would be the formulation of a fluid with controlled compressibility, something like a liquid filled with small individual cells of foam rubber. Thus compressibility would be a function of cell concentration.

Concrete Example of Cargo Aircraft Floor Strength

Concrete floors in skyscrapers, made of 1-foot thick concrete interlaced with a mat of 3/8-inch reinforcing steel every 2 inches, are not as strong as cargo floors in the C-130 A transport plane, according to C. L. Johnson, Lockheed chief engineer. Such concrete floors are built for loads of 250 pounds per square foot. With integrally stiffened fabrication—floor and supporting structure made of a single slab of duraluminum—the turboprop aircraft floor carries loads of 300 pounds per square foot, with considerable weight savings.

Megawatt, Megacycle, Megabuck

One of the most unusual pseudoengineering terms reported recently is "megabuck," used by the Atomic Energy Commission, according to one source, in referring to a million dollars. By the same line of reasoning, the government spender of a million dollars should probably be called a "megabuckaneer."

Glass-Fiber Cushioning Has Controlled Spring Rate

By means of a patented stabilizing process, resiliency, spring rate, vibration absorption characteristics and space requirements of a new glass-fiber cushioning material can be varied to provide the combination desired. According to Glass Fibers Inc., "Vibraglass," the resilient board material was originally designed as a shock cushion and thermal expansion material for solid propellants in rocket-powered missiles. Made of glass fibers compressed and bonded into millions of highly flexible "glass springs," the material has characteristics which can be varied by fiber orientation, quantity and nature of binder, pad thickness, density, and degree of stabilization.

New Process Makes Shapely Packages

Contour packaging—a relatively new technique in which products are nested snugly between two formed sheet-plastic layers—may get additional impetus from a forming process developed by The Auto-Vac Co. Vacuum forming of thermoplastic sheets is usually used to make the skin-tight containers, which effectively protect all types of products—delicate instruments to golf balls—from physical damage. Chief advantage of the new method is its speed compared with older manual methods.

"Chinese Water Torture" Inflicted on TV Screens

One early test used to measure adherence of phosphor screens to face-plates of TV tubes involved dripping mercury slowly from a height of 10 to 14 inches on the screen, placed at a 45-degree angle. Under certain conditions, as many as 1400 drops of mercury were required to produce a hole 1/16-inch in diameter in screens employing potassium sulfate. With screens using barium nitrate, however, only 10 to 20 drops were required.

MACHINE DESIGN

JUNE 1953

For Faster Drying Behind the Ears

AT this time of year, with droves of college graduates flocking into industry, it's a safe bet that in more than one place the orientation period will be followed by considerable disillusionment, both of graduates and their new bosses. The latter will have been hoping against hope that the new crop will be better informed and better trained to cope with current problems. Alas for their hopes, the humidity behind the ears will seem higher than before, and the continuing preoccupation of educators with "academic theories" will be condemned in language more picturesque than accurate.

By and large the engineering colleges are doing an excellent job, though the educators themselves will be the first to admit that there is room for improvement. Those who so glibly criticize engineering education might well pause to consider whether they themselves have ever done anything to help the colleges do an even better job. Does their interest in their own alma mater or local institution extend beyond the current shortcomings of the football coach? Have they ever visited the engineering school to get acquainted with the faculty and discuss mutual problems? Education, after all, is essentially a process of handing on what mankind has learned, so that the next generation can go on from where the earlier ones left off, and to accomplish this there must be open lines of communication between practicing engineers and engineering professors at the working levels.

Recognition of a share in the responsibility for education is one of the hallmarks of a profession; the extensive use of practicing doctors and lawyers in medical and legal professional education should have its counterpart in engineering. In the absence of a nationwide policy for the engineering profession, individual engineering executives have a tremendous opportunity to make a contribution by initiating programs of co-operation in their own areas.

For instance, temporary interchange of machine design professors and working design engineers between colleges and industries in the same locality, which has been done on a limited scale, offers profound mutual benefits. The professors gain a practical slant which is passed on to the students. The students also gain from exposure to practical working designers. The design engineers, in turn, consolidate their own understanding of engineering principles through the necessity of imparting them to the students. The companies gain through the improvement of their own engineers, through the detached viewpoint which the professors can bring to bear on current problems and, ultimately, through the opportunity to hire better graduate engineers.

Such a plan, wisely carried out, can greatly assist the colleges to turn out practical-minded graduates who can more quickly contribute effective engineering manhours to the problems at hand. In short, it can speed up drying behind the ears.

Colin Carmichael

EDITOR

Successful Product Design =

By I. F. Kinnard
Mgr. of Eng.
Meter and Instrument Dept.
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West Lynn, Mass.

LAST year in the measurements field alone, about one thousand new products were placed on the competitive market.[1] Some of these will succeed—others will not. In many cases, success or failure will be directly traceable to the design engineering of the product, for largely in this stage the quality of the completed device is determined. It is the intent of this article to introduce a systematized approach to product design—an approach which experience has shown will enable the engineer to insure in advance a greater measure of success.

In general, engineering consists of applying scientific methods to obtain a specific practical result. In the measurement industry, as well as in many others, the engineer occupies a key position because of the scientific nature of the products manufactured. It has been said that the chief function of a sales operation is to obtain orders, that of manufacturing, to produce a quality product at competitive cost. It is the function of engineering to make both of these possible.

The specific practical result which is the product of good engineering may also be considered as the consummation of a sound design. To attain this goal, the engineer must achieve in the design the following qualities which, taken together, make up a sound design philosophy:

1. Technical excellence
2. Attractive appearance
3. Mechanical nicety
4. Suitable manufacturing cost
5. Availability at the proper time

Each of these is important in every design, although their relative importance in a specific design is dependent upon the particular circumstances involved, such as market requirements, status of the art, delivery promises, and other considerations. In this article each of these five points will be examined to assist the design engineer in evaluating his product from this viewpoint and to outline more clearly his responsibility.

Technical Excellence: A product may be said to have technical excellence when it gives the optimum performance of the operation for which it was designed, in terms of accuracy, efficiency, over-all reliability and convenience. Technical excellence can be achieved primarily through sound and creative technical thinking, careful calculations, and painstaking tests.[2] That is, the objectives are clearly understood, the design is founded on sound engineering principles, decisions are based upon facts, not opinions, and a scientific approach is taken to the problem.

The following steps[3] may be useful as a guide in providing technical excellence in a new product design:

1. Identify by careful analysis each basic functional element and characteristic of the proposed device that is important to its over-all operation.
2. Set up desired quantitative performance specifications for each functional part and the complete device.
3. Make careful analytical study of proposed device and determine its probable performance.
4. Make experimental determination of actual performance characteristics of the device as a whole as well as for each significant basic element. Reconcile these characteristics with theory.
5. Make over-all evaluations and comparisons with the desired results.

Such a procedure was followed in the design of the exposure meter illustrated in *Fig.* 1. Here, in addition to other features, a predetermined logarithmic-scale distribution was desired so that the instrument scale and pointer could be made to function as parts of a slide rule for computing exposure from the light indication. Conventional instruments[4] require the pho-

---

[1] References are tabulated at end of article.

TECHNICAL EXCELLENCE
ATTRACTIVE APPEARANCE
MECHANICAL NICETY
SUITABLE PRODUCTION COST
AVAILABILITY AT PROPER TIME

tographer to read the scale and then set the observed value on the calculator before determining the exposure. These two steps are eliminated with the true logarithmic-scale distribution of this instrument. The accomplishment of such a distribution was brought about by a unique construction of permanent magnet, core, and flux distributor in the instrument mechanism developed as a result of careful analytical study together with a well-organized development program.

To provide technical excellence, the engineer must be constantly on the alert to find ways and means of utilizing better techniques and materials, as well as applying principles which are basic and which accomplish the desired result in the most direct and efficient manner. It is this type of thinking and research which provides any product with the quality of technical excellence.

Good engineering cannot trifle with facts nor temporize with truth. It may be difficult sometimes to understand the thrill of attainment that comes to an engineer, or to any worker, who finds that he has discovered a way of solving a difficult problem or a way of building some device better than it has ever been done before. Such an accomplishment can be arrived at in no other way than by knowing the facts and working out the solutions based on scientific or engineering truths.

Behind many new developments are original ideas, very often in the form of inventions. These ideas may represent the ground work for some great accomplishment, but they can only be brought to fruition if they are firmly anchored in accurate technical thinking and their development or reduction to practice carried out in a sound and practical manner.

Technical excellence implies the proper use of materials, theory, and manufacturing processes to obtain a high-quality product. It is founded upon the research and development which have preceded it and which make the expected results possible.

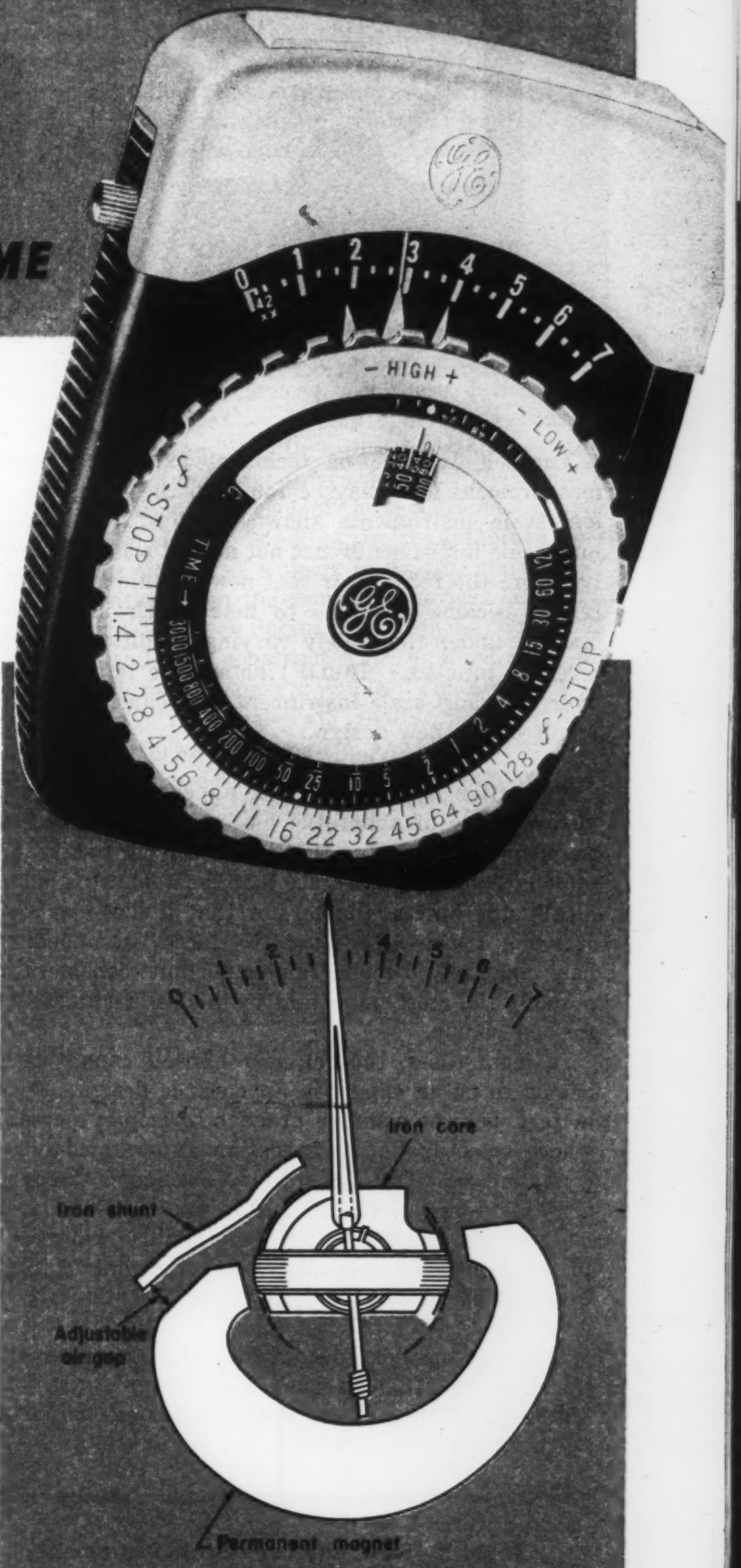


Fig. 1—Exposure meter with logarithmic-scale distribution for serving as part of a slide rule. The adjustable iron shunt permits proper calibration over entire scale

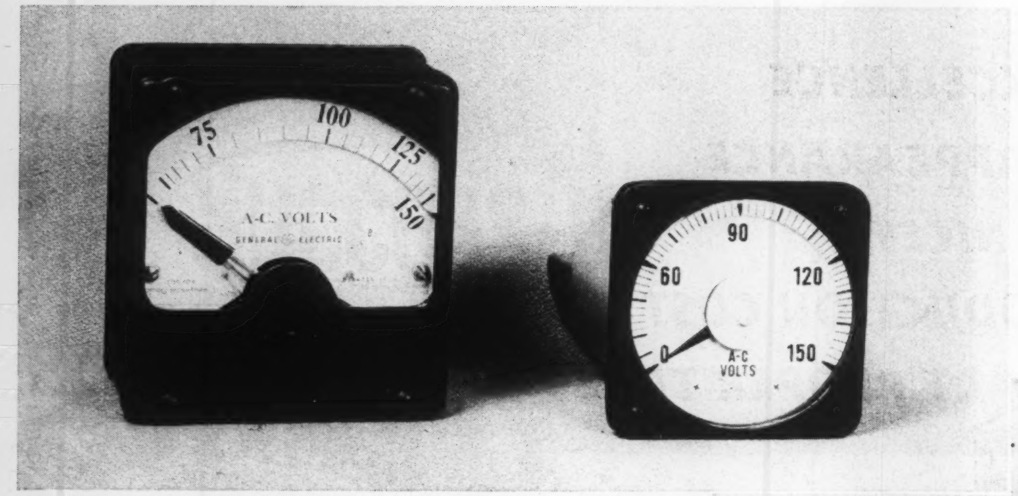
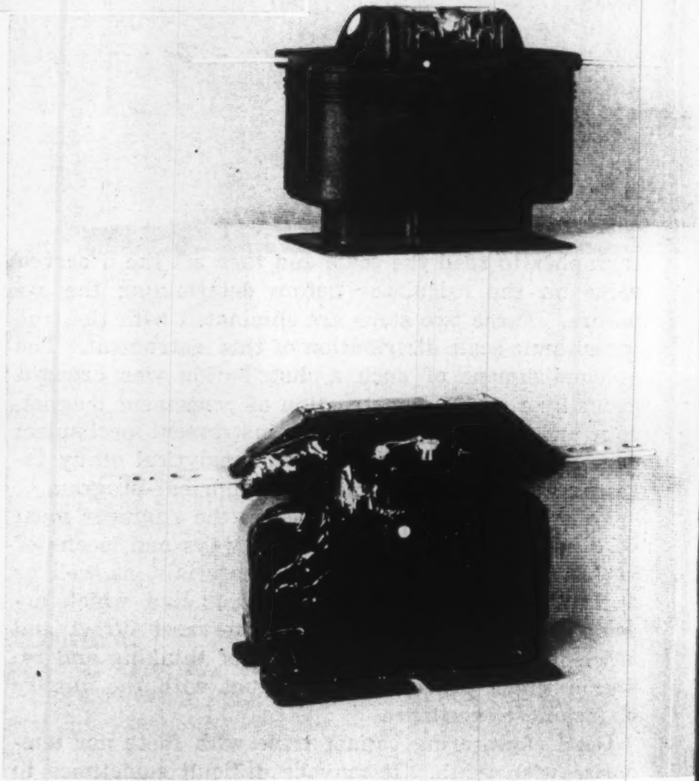


Fig. 2—Left—Switch board ac voltmeters of short-scale type, left, and long-scale type, right. Pertinent factors are compared in Table 1

Fig. 3—Below — Comparison of new, above, and old instrument current transformers, showing improved appearance of the new design



Another example of technical excellence in the measurement field may be found in the design of the long-scale instruments shown in *Fig.* 2. Although long-scale instruments[5] are not new, it was only shortly before the recent war that new techniques and materials became available to make such instruments feasible under the widely varying conditions encountered in practice. TABLE 1 shows the improvements over the short-scale instrument that came about as a result of the new design.

Attractive Appearance: The appearance of any device or piece of apparatus has never before received the attention in design that it is receiving today. It is no longer sufficient to state that the apparatus is technically the best available, nor that it has many outstanding features, because the factor of appearance has rightfully become an important consideration, possibly the most important to the less technically informed person.

In most cases, the engineer himself cannot be expected to be an expert in appearance design. It has, in fact, become common practice to employ personnel whose sole function is to design apparatus having a complimentary first impression. Although the details of styling may not fall within the province of the engineer, it is clearly his responsibility, however, to plan for it in his over-all design program and to take every measure necessary to insure the attractive appearance of his finished product.

Many companies specify that the apparatus they purchase must blend with related units previously designed. Here again appearance becomes important.

Table 1—Short and Long-Scale Instruments

Property	Short Scale	Long Scale
Case size (inches)	6.5 sq.	4.25 sq.
Instrument weight (pounds)	3.75	2.9
Scale length (degrees)	105	250
Scale length (inches)	5.2	7.1
Moving system weight (grams)	1.8	3.09
Factor of merit (torque/weight)	1.06	1.36
Response time (seconds)	1.8	1.3

The basic principles of good composition—unity, balance, proportion, and harmony—applied to a design can convey to the observer a sense of high quality, durability, or functional simplicity which will predispose him to look favorably on its technical attributes.

Comparison of the old and new instrument current transformers[6] shown in *Fig.* 3 graphically illustrates the neater and more attractive appearance of the new design. The improvement was recently accomplished in a General Electric transformer having butyl molded insulation. This insulation provides a technically superior product having radically improved appearance, and has revolutionized design and manufacture of dry type instrument transformers.

Mechanical Nicety: The term mechanical nicety undoubtedly creates varied pictures in the minds of different individuals. In order to avoid too broad an interpretation of the term, therefore, it will be defined for the purpose of this article as "cleanness and purposefulness of construction and mechanical precision of parts." "Cleanness and purposefulness of construction" is a term applying to one's mechanical sense and relates to mechanical harmony rather than appearance from an aesthetic standpoint.[7]

Mechanical harmony cannot, in the strict sense, readily be seen and yet it does incorporate certain elements such as smoothness of finish, suitability of parts, and functional simplicity which imply ease of manufacture, maintenance and adjustment and give the effect of unity in the design.

Determination of mechanical nicety requires examination by a trained observer on the basis of these qualities of mechanical harmony plus the optimum mechanical precision of the parts. The experienced and technically trained person will immediately sense whether or not a device has mechanical nicety although he may find it difficult to express in words exactly what he means. This situation is somewhat akin to that of an artist who can recognize a real work of art but is often unable to convey his reasoning to one who does not have his appreciation of the subject.

In engineering for mechanical nicety, the designer should keep the following principles in mind:

1. Simplify the design.
2. Use unit construction where possible.
3. Design parts for the specific service intended.

In simplicity of design is found the very essence of cleanness of construction so important to mechanical nicety. With such a design, the simplest complete device is possible with every part relatively easy to manufacture and performing a maximum number of functions. This will result in few parts, simple shapes, and will contribute greatly to mechanical nicety.

The principle is demonstrated in the hook-on wattmeter depicted in *Fig.* 4. In this design, the current transformer used in conventional hook-on instruments has been eliminated by the use of a specially designed hook structure which supplies the field flux directly to the moving system.[8] The over-all design is further simplified by making the magnetic hook structure perform a number of very important functions which result in simplified phase-angle correction, linear hook-current, field-flux relationship, minimum hook weight, and insulation of the current from the potential circuit. Various kilowatt ranges are made possible by switching the potential circuit resistance. Thus, a design has been developed which uses a simple construction to perform the accurate measurement of power by the "hook-on method."

Unit construction may be considered as the natural outgrowth of simplification of design as it is applied to more complicated devices. In these devices it is generally impractical to develop a design containing only a few parts and it is therefore desirable to evaluate the use of functional subassemblies. Design of a single physical unit for each of these functional groupings provides easier handling in manufacture and maintenance since it is simpler to control and inspect each unit rather than the completed device. Through unit construction, each subassembly can be considered separately and thus constructed in the most rigid, direct, and effective manner possible. The assembly of the units into the whole will therefore result in a more straightforward, accessible, and efficient over-all product. Such a device has greater mechanical stability, and greater sustained accuracy of performance will result.

The application of the third principle, design of original parts for the specific service intended, requires sound engineering judgment. A design that just grows out of an existing device by the addition of a quantity of single-purpose parts simply for adaptation to a service for which it was never intended is neither creative nor, in the long run, economical. It

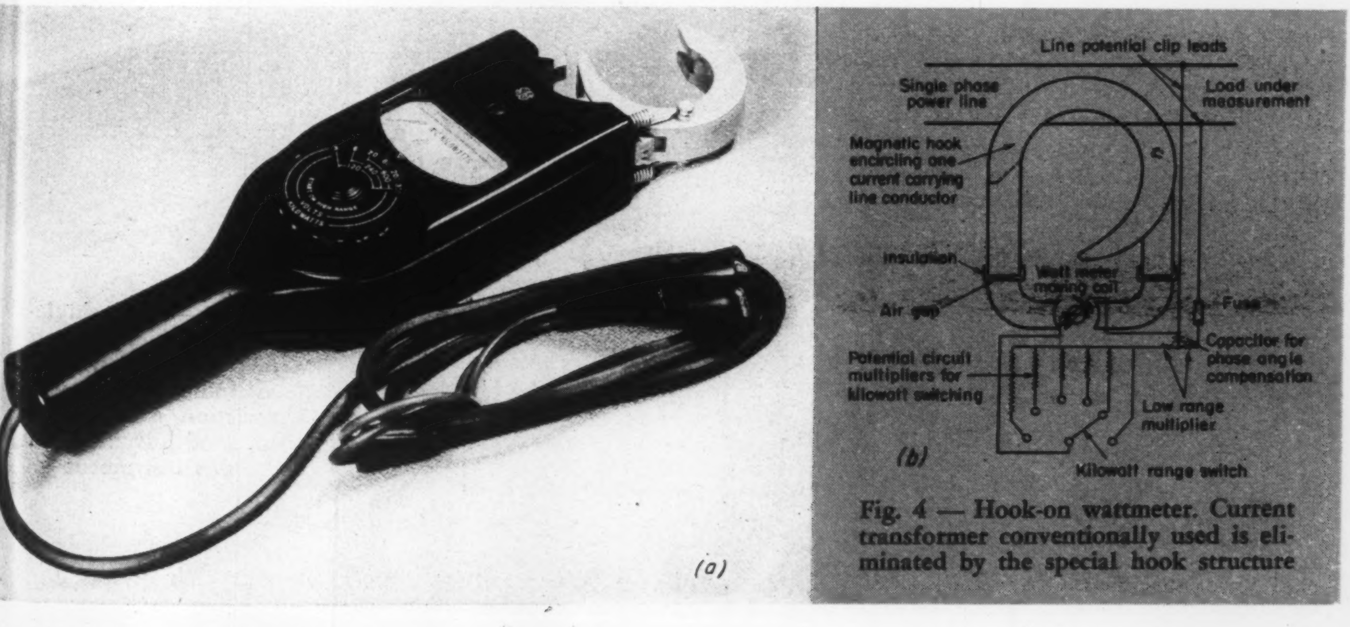

(a)
Line potential clip leads
Single phase power line
Load under measurement
Magnetic hook encircling one current carrying line conductor
Insulation
Watt meter moving coil
Air gap
Fuse
Capacitor for phase angle compensation
Potential circuit multipliers for kilowatt switching
Low range multiplier
(b)
Kilowatt range switch

Fig. 4 — Hook-on wattmeter. Current transformer conventionally used is eliminated by the special hook structure

is, on the other hand, never good engineering to undertake a design with no regard for previous work in the field. Standardization is always an important consideration in manufacturing, and the judicious use of parts which are already available to perform the service in question is not only permissible but highly desirable.

An example of a device in which unit construction is used effectively is the watthour meter shown disassembled in *Fig.* 5. This meter is new in its conception, its design, its operation, and in its use of modern materials and techniques.[9] These design features combine to assure permanence and stability of calibration; they assure lower maintenance costs, greater ease in handling and greater sustained accuracy than has previously been achieved in a watthour meter.

Suitable Manufacturing Cost: Free enterprise has made it necessary for industry to turn out products which not only excel from a technical standpoint but which must be competitive in price. In the industrial world, nothing can live that cannot compete, and one of the most prominent factors in competition is cost.

The engineer, as the one who establishes the basic product design, exerts a major influence on final cost. In most instances, an acceptable selling price has been established before the product has progressed very far in the design stage. Cost analyses made in these early stages frequently show up features involving unnecessarily high labor and material charges at a time when alteration of the design to correct them may be a reasonably easy task. It is the responsibility of the engineer to study the results of such analyses and to use every available means to reduce these labor and material charges since they are the only factors he has to deal with in achieving low costs.

One of the engineer's greatest resources in eliminating undesirable expense is to check his design on the basis of the principles already discussed under mechanical nicety. Also, a study should be made of each functional part to determine the reason for its use and whether or not the function can be performed less expensively by some other means. A design in which the ultimate in simplicity has been achieved, in which each part is designed for its specific function or functions, and in which unit construction has minimized the number of separate assembly operations required, will obviously go far toward meeting the economic objective.

A cardinal principle in achieving suitable manufacturing cost is the utilization of proved techniques and readily available materials, since the most economical designs are generally those which take full advantage of existing manufacturing know-how and equipment. In seeking economy, however, the engineer must never neglect progress. The development work which is necessary to apply a new material or process may appear long and costly at the outset, but ultimately a technically superior product at a comparable or even lower cost may result. The entire trend of technical progress through the years has proved this to be true.

This fact is evident by the advances made in permanent-magnet alloy development. The newer alloys are characterized by greatly increased magnetic energy over alloys previously available. In many cases, the cost of the completed magnet having the higher energy value may be more than for the magnet used in older constructions. However, its decrease in size and weight together with the better performance frequently result in a lower cost of the functional unit or the complete device, thus justifying the increased cost of the permanent magnet alone.[10] In fact, these new materials have given new impetus to designers of permanent magnets for a wide range of applications, particularly in the electrical measuring instrument field. In addition to lower costs, superior performance has been and continues to be possible from this development alone. Similar instances in the field of other materials and processes could be cited to show how technical progress through the years can contribute to lower manufacturing costs and also result in superior products.

Even after a device has been placed in production, engineering effort toward lowering its cost must continue. The design should be the subject of constant

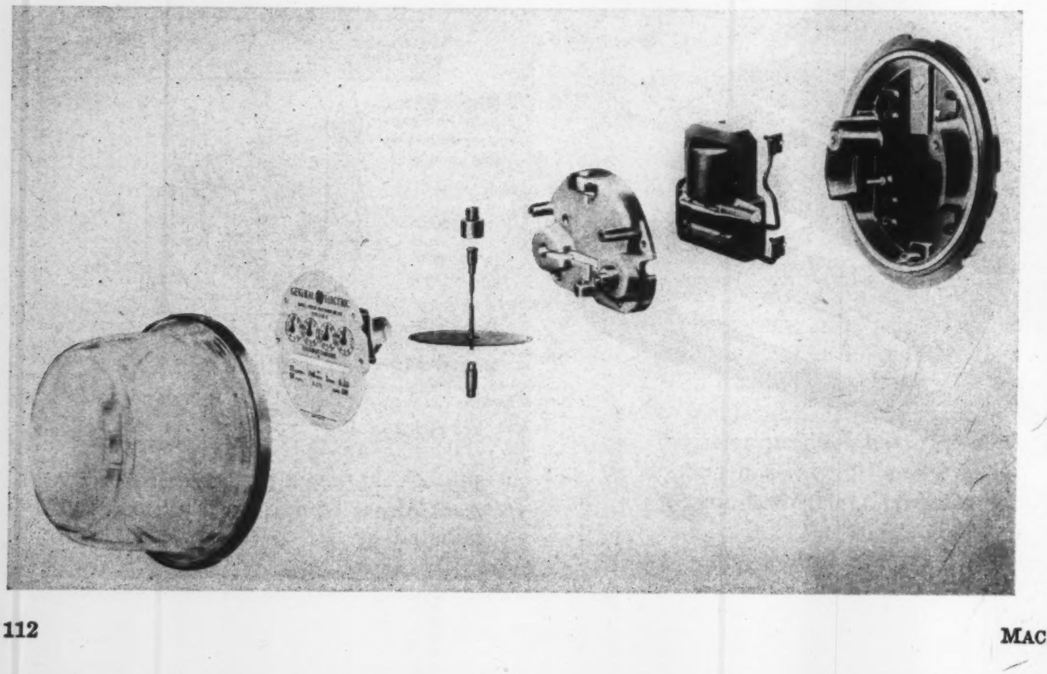


Fig. 5 — GE single-phase induction watthour meter shown disassembled. Unit construction is employed to good advantage in this instrument

study from the standpoint of reducing its labor and material content without impairing its technical excellence. The cost reductions thus effected will be helpful in offsetting inflationary trends and in widening the available market. As with original designs, moreover, cost-reducing changes in labor and materials made on production items frequently result in actually improved performance.

Illustrated in *Fig.* 6 are two general-purpose time switches designed for similar circuit applications. However, the newer switch at the right uses only 30 parts to perform the same functions as the 62 parts required in the switch at the left. These parts are shown in the illustration from which it is possible to observe several outstanding features. The new construction uses flat punchings instead of molded parts and the parts are of a much simpler design. In addition, the newer design uses only one spring as contrasted to the four used in the other. No leads are required in the design shown on the right, the blades being punched directly out of flat stock. Despite the radical change in design and reduction in the number of parts, the new switch gives more reliable operation. This example truly illustrates what can be done by applying engineering effort in a constant study towards reducing cost in an already established product.

Availability at the Proper Time: The final element, availability at the proper time, should now be examined. This requirement applies not only to the meeting of production dates on scheduled items, but particularly to the availability of new and improved designs which are suited to meet the needs of new markets when they occur or can be developed.

Not too long ago, the idea of scheduling original development work was almost unheard of. As organizations have grown in experience, however, it has gradually been realized that most developments leading to practical designs follow a more or less familiar pattern. Today definite time schedules are usually set up for the completion of even the preliminary part of a program which may involve considerable creative work and even invention. It is, of course, not always possible to complete such work on schedule, but the fact that a schedule has been established is a powerful factor in emphasizing the importance and the value of timing.

After preliminary development has been completed and satisfactory working samples are available, realistic schedules can be set up for the completion of design, preparation for manufacture, and initial production. The successful engineer must learn to

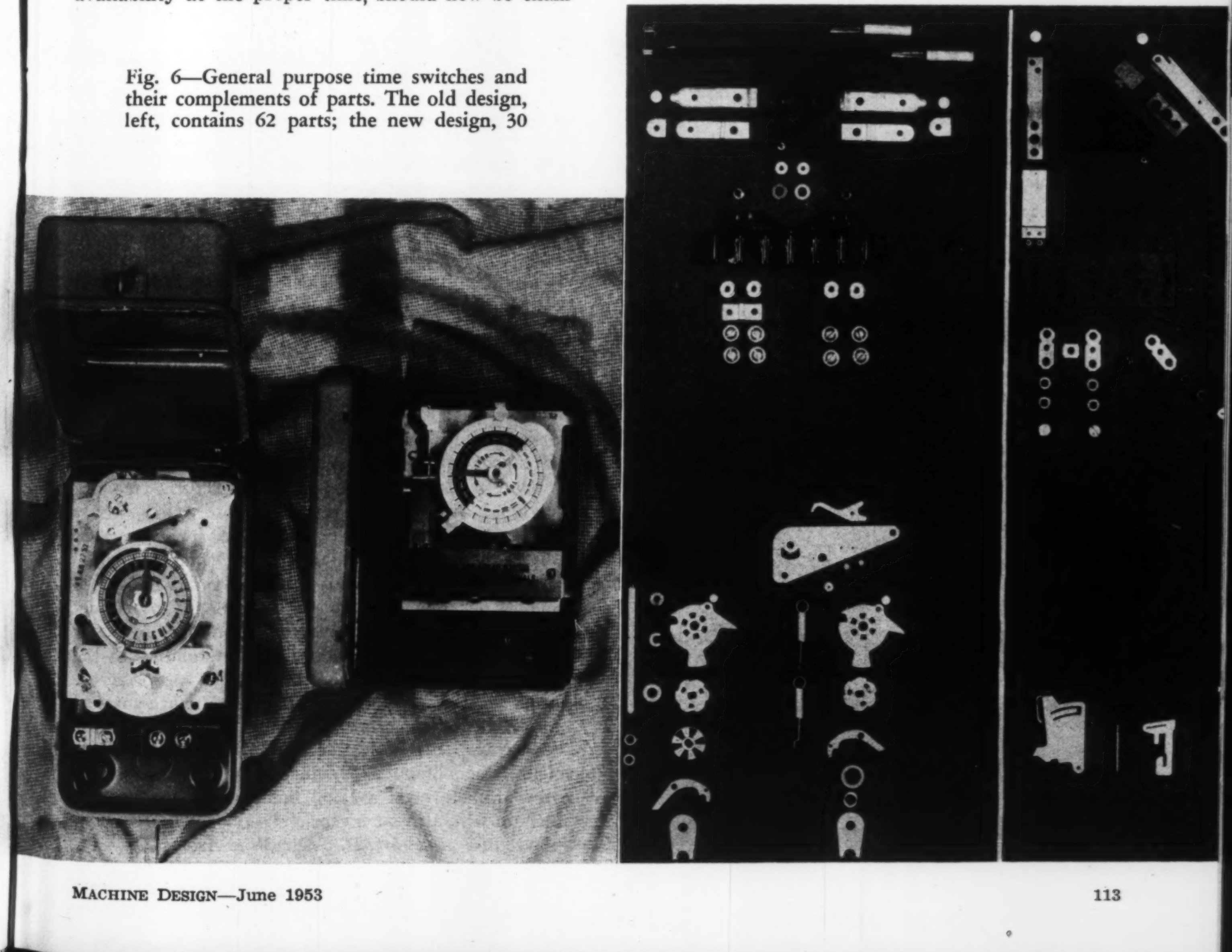


Fig. 6—General purpose time switches and their complements of parts. The old design, left, contains 62 parts; the new design, 30

recognize the importance of meeting such schedule dates as nearly as possible, and to evaluate the problems before him so that work will be started soon enough to insure that the proposed product will be available at the time it is actually needed.

As previously pointed out, however, engineering for availability at the proper time implies not only fulfilling definite production committments, but in a broader sense, filling new demands occasioned by advancing technology in other fields, and even creating such demands by means of invention.

There must be a constant looking-ahead to determine the needs in the years to come and to plan today for meeting these needs adequately. The engineer has ceased to make progress when he concerns himself only with today's and tomorrow's products and not with those which must become available in future years. To look ahead is essential if he is to fulfill his professional obligations and to justify the confidence placed in him and his work. The future will require new products for new markets, and his thinking must be sufficiently in advance of the times to make these designs available as soon as the need for them has become apparent.

The Challenge: Characteristics and acceptance of any product depend to a large degree on the type of engineering that goes into it. In this article, five essential considerations have been presented as the basis for an orderly approach to successful product design. The emphasis here has been placed upon design in the field of measurement equipment, but it is by no means in this area alone that these considerations are important. The success or failure of any new product may well depend upon how well it meets the challenge of technical excellence, attractive appearance, mechanical nicety, suitable manufacturing cost, and availability at the proper time.

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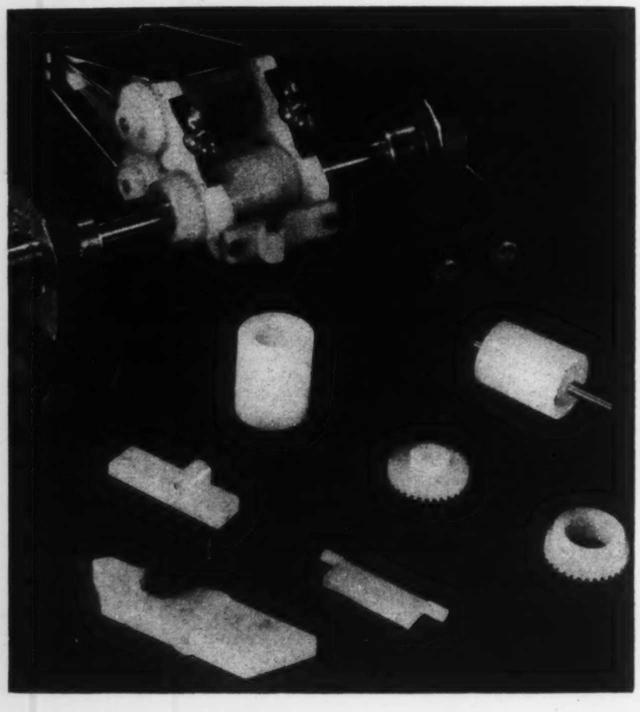
Nylon Parts Improve Spinning Units

RESILIENCE of nylon gears and bearings in long-draft spinning units permits individual units to be removed and replaced in a matter of seconds without stopping the spinning machine. Since the average spinning machine incorporates 200 to 400 of these units and the total number in a mill may be as high as 300,000, savings in downtime are appreciable. Danger of yarn contamination by oil is also eliminated as nylon requires no lubrication.

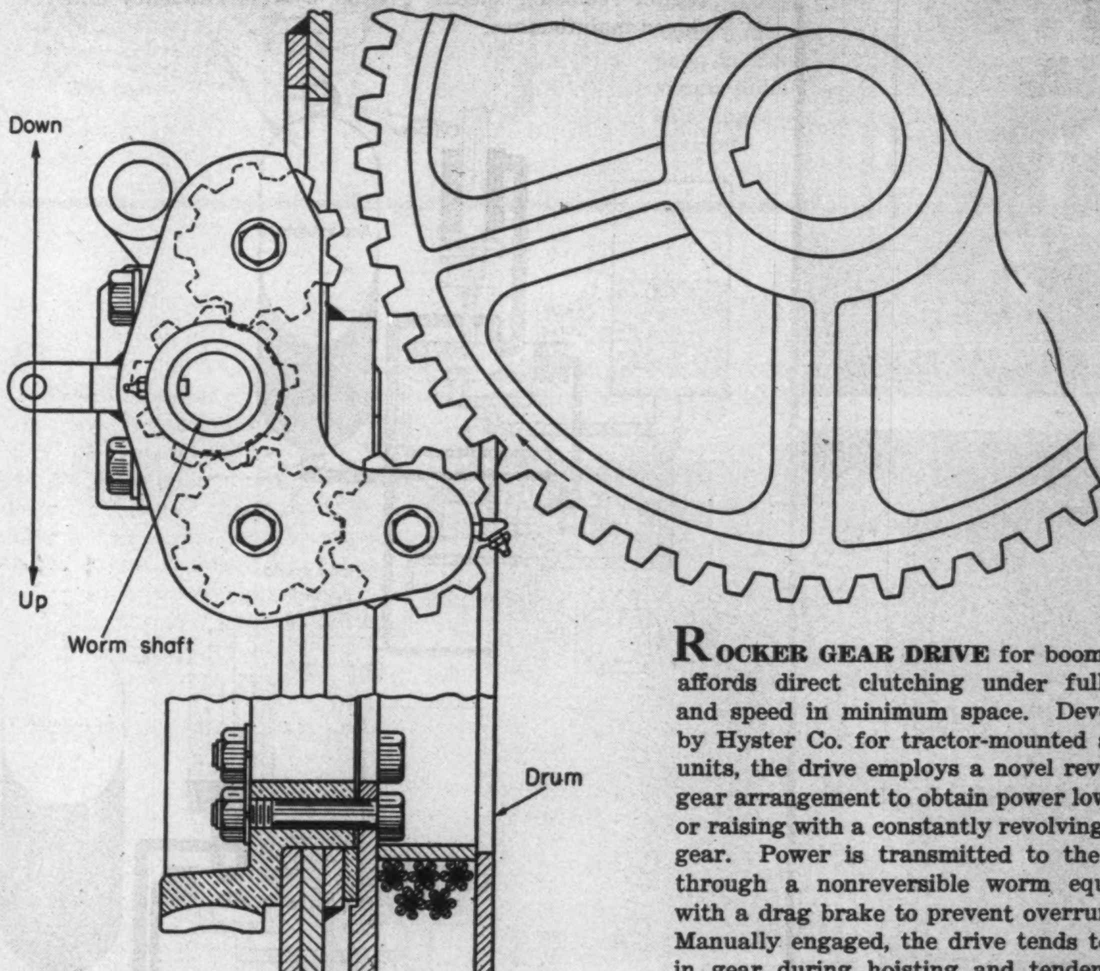
Full-scale production of these units by Macdonald and Sons Inc. was undertaken only after extensive trials, which indicated that use of the molded Du Pont nylon results in a low power requirement, attributable to a low coefficient of friction, and weight reduction of 75 per cent.



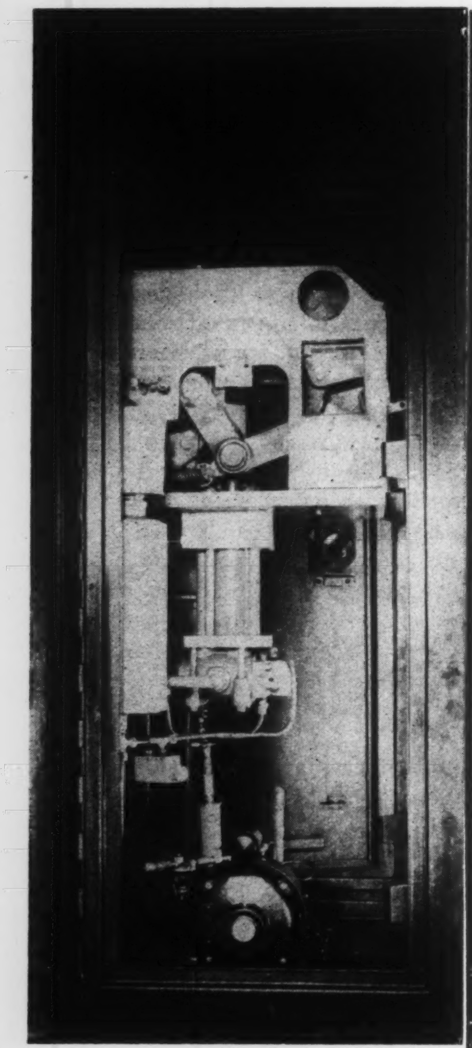
"Since 1940, the ratio of productivity of private workers and 'corporate' investigators has changed and is continuing to change in favor of the group of team workers. The demands upon the modern individual and on the group inventors are vastly greater today. In order to produce inventions of value, there must be available to the inventor a background of knowledge of all phases of industry's problems for development or research. The inventor must have a more comprehensive education than formerly and above all, he needs a basic understanding of the fundamentals of all of the sciences with a good measure of mechanical skill and aptitude and mathematical knowledge and experience thrown in for good measure.

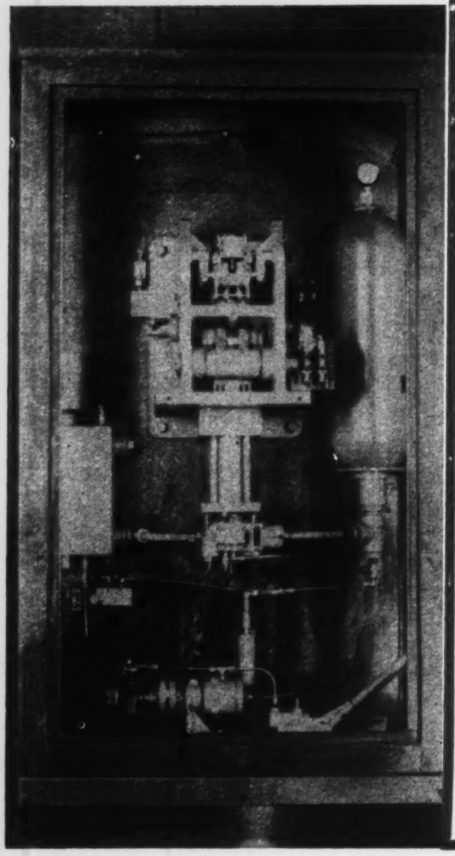
"Because of the increased complexity of modern science, technology and industry, it seems more and more unlikely that a lone, independent worker can come up with a great invention"—HAL F. FRUTH, *consultant and physicist, H. F. Fruth & Associates.*

SCANNING the field for IDEAS

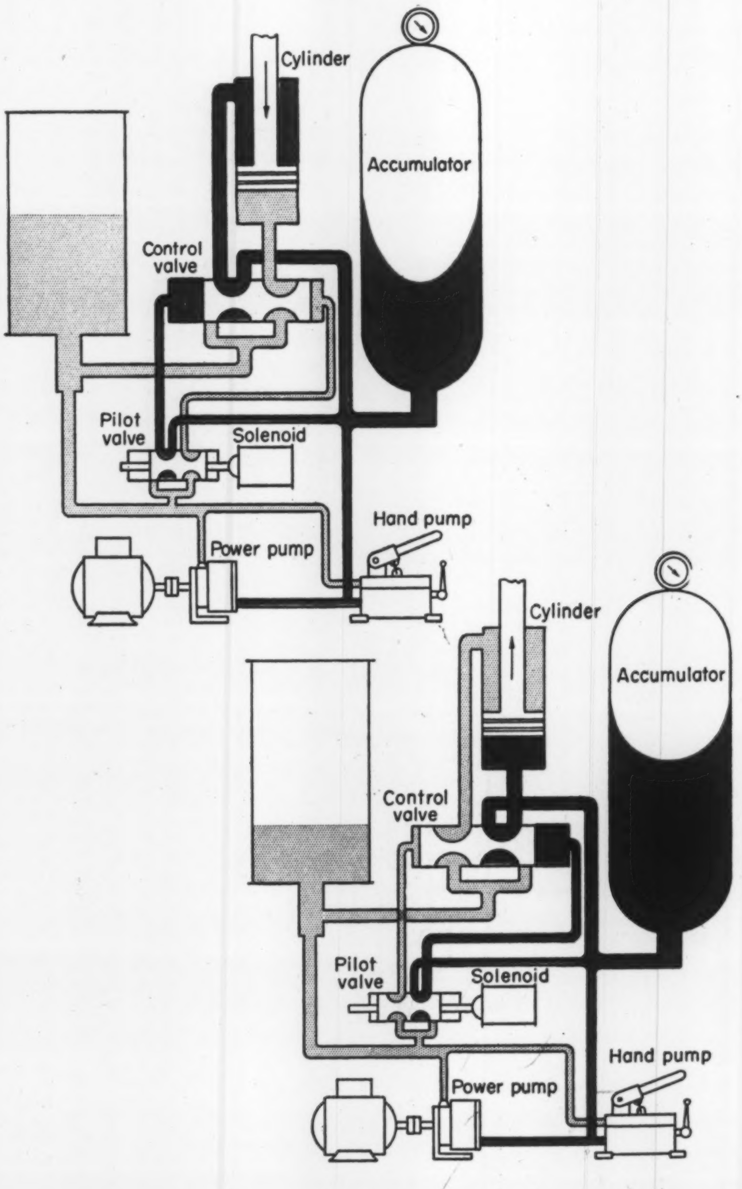


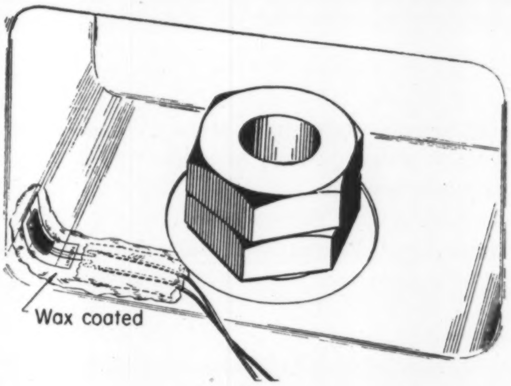
ROCKER GEAR DRIVE for boom hoist affords direct clutching under full load and speed in minimum space. Developed by Hyster Co. for tractor-mounted shovel units, the drive employs a novel reversing gear arrangement to obtain power lowering or raising with a constantly revolving drive gear. Power is transmitted to the hoist through a nonreversible worm equipped with a drag brake to prevent overrunning. Manually engaged, the drive tends to lock in gear during hoisting and tendency to drive out of mesh during lowering is easily overcome by hand lever. Engagement under full speed and load is facilitated by the radial, rather than axial, engagement. The drive can pull up to 7000 pounds or safely hold more than 21,000 pounds and readily withstands the shocks of improper engagement.





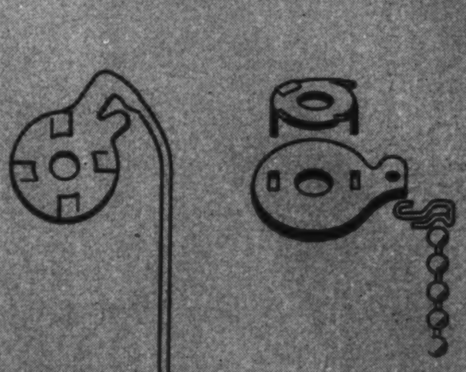
INSTANTANEOUS ENERGY RELEASE for closing high-capacity circuit breakers is attained hydraulically with a unit developed by Allis-Chalmers Mfg. Co. Utilizing a hydropneumatic accumulator for energy storage, the system has been designed to meet demands which may, in a single closing operation run as high as 130,000 inch-pounds of energy delivered during $1/8$-second, or approximately 175 horsepower available instantly. Solenoid-actuated pilot control achieves high operating speeds. System pressure is 3000 psi and a commercial oil having a nearly flat viscosity curve is employed to meet the varying temperature conditions encountered. Component sizes and weights are minimized by using flow velocities considerably above those for continuous flow. In addition, an emergency hand pump provided in the system may be also used to lock the circuit breaker positively in any position for maintenance or inspection. Advantages of the hydraulic system over conventional operators include higher reclosing speeds, greater system efficiency and reduced maintenance.

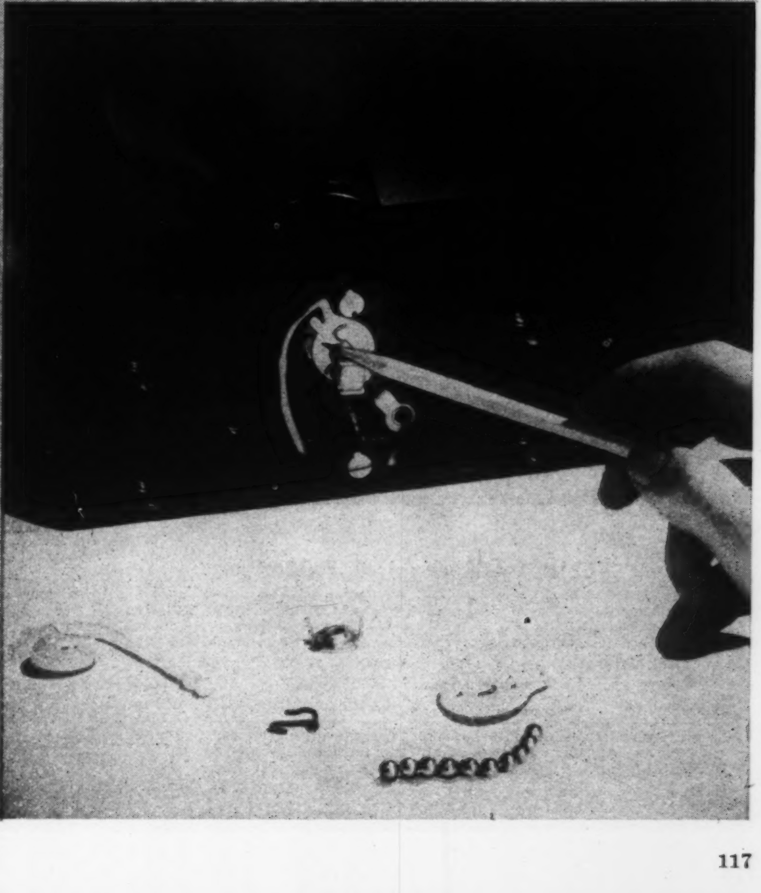

Cylinder
Accumulator
Control valve
Pilot valve
Solenoid
Hand pump
Power pump
Cylinder
Accumulator
Control valve
Pilot valve
Solenoid
Hand pump
Power pump



MAXIMUM PRECISION in leveling large machines, essential for optimum performance, can be obtained with integral strain gages. Developed by Michigan Tool Co. for large gear shavers, the use of strain gages affords leveling accuracies to within 0.0003-inch and facilitates duplication of installations. Uniform distribution of loads and deflections on leveling jacks and pads is assured. Maximum sensitivity of strain indication is provided by attaching the gages on a radius of the tie-down bracket.

ONE-PIECE NYLON RATCHET and pull arm serves a dual purpose—wear resistance and resilience—in a new lamp socket switch mechanism developed by Monowatt Div. of General Electric Co. The single part, molded with a flexible arm, replaces the conventional four-piece design which required a ratchet, insulator, short length of chain and attaching hook. In addition, the new design eliminates shock regardless of humidity conditions, reduces production costs and provides dielectric strength sufficient to withstand 250 volts.





17% Chromium Stainless

WITH many materials, the need for redesign to take advantage of ready availability is less urgent than during the past few years. However, such is not the case with nickel, which is difficult to obtain now and will probably remain so in the immediate future. Since nickel-bearing stainless steel consumes almost half the U. S. nickel supply, substitution in this area is well worth the critical attention of the cost-conscious designer.

Among the most versatile materials for conversion purposes are the 17 per cent straight chromium stainless steels. Conversion, even though economically justified, always involves a certain amount of fuss and bother. Service characteristics of the alternate are usually somewhat different, the design may have to be revised, and processing methods may undergo a change. But 17 per cent chrome stainless presents the fewest problems; utilization of this material can be effected with a minimum of difficulty.

Type 430, free-machining type 430F, and welding grade type 430T most nearly approach the popular type 302 and 303 chromium-nickel stainlesses in strength, corrosion resistance, weldability and formability. In durability, attractiveness and economy, type 430 stands out. The specific design factors which must be taken into account are appraised in the check list following. Each phase should be considered carefully in arriving at a final decision.

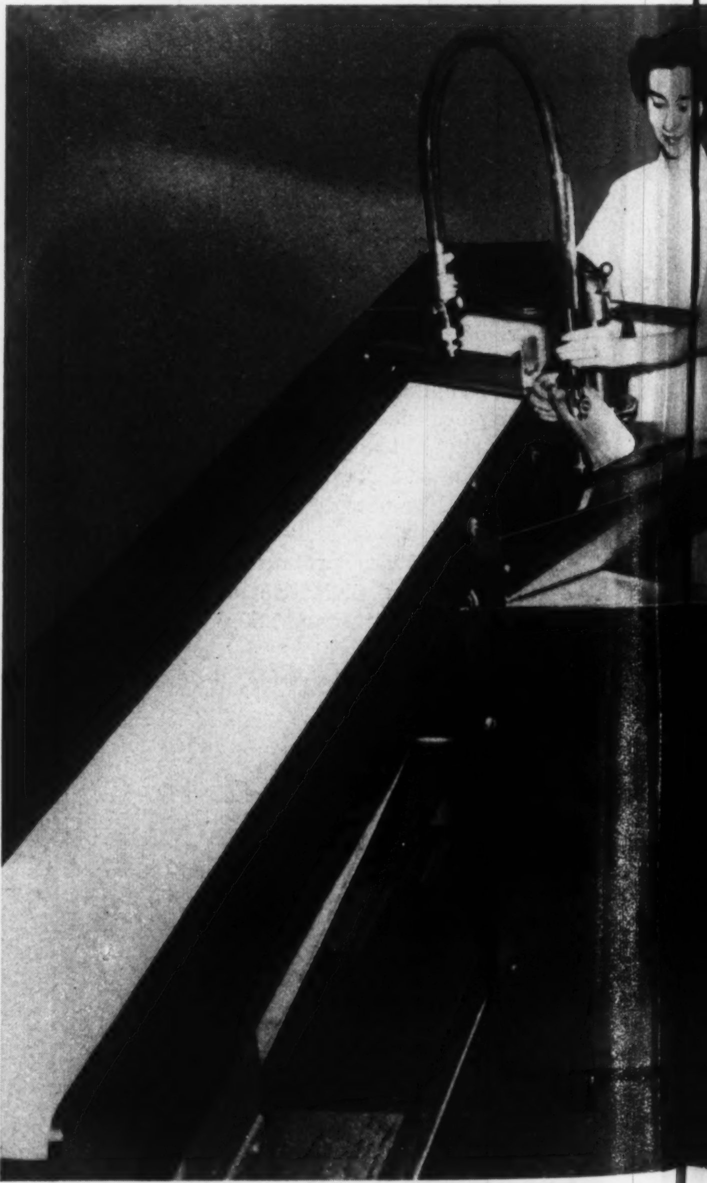
Corrosion Resistance: In general, type 430 stainless and its modifications are less corrosion resistant than the 18-8 chromium-nickel type 302. But for certain specific corrosive situations, type 430 can often do as good a job as type 302. In the absence, however, of actual service data, it is strongly recommended that corrosion investigations be conducted before replacing type 302 with type 430.

Mechanical Properties: Designers who have been accustomed to the 18-8 stainless grades will find cer-

Table 1—Mechanical Properties

Property	Type 302*	430*	430T*	430F†
Ultimate tensile strength (psi)	90,000	75,000	65,000	80,000
Yield strength‡ (psi)	40,000	45,000	45,000	55,000
Elongation (% in 2 in.)........	50-55	25	30	25
Hardness	85 Rb	85 Rb	78 RB	170 Bhn

*Annealed sheet. †Bar stock. ‡Fatigue strengths for 302 and 430 are approximately one-half the tensile strengths.



Steel

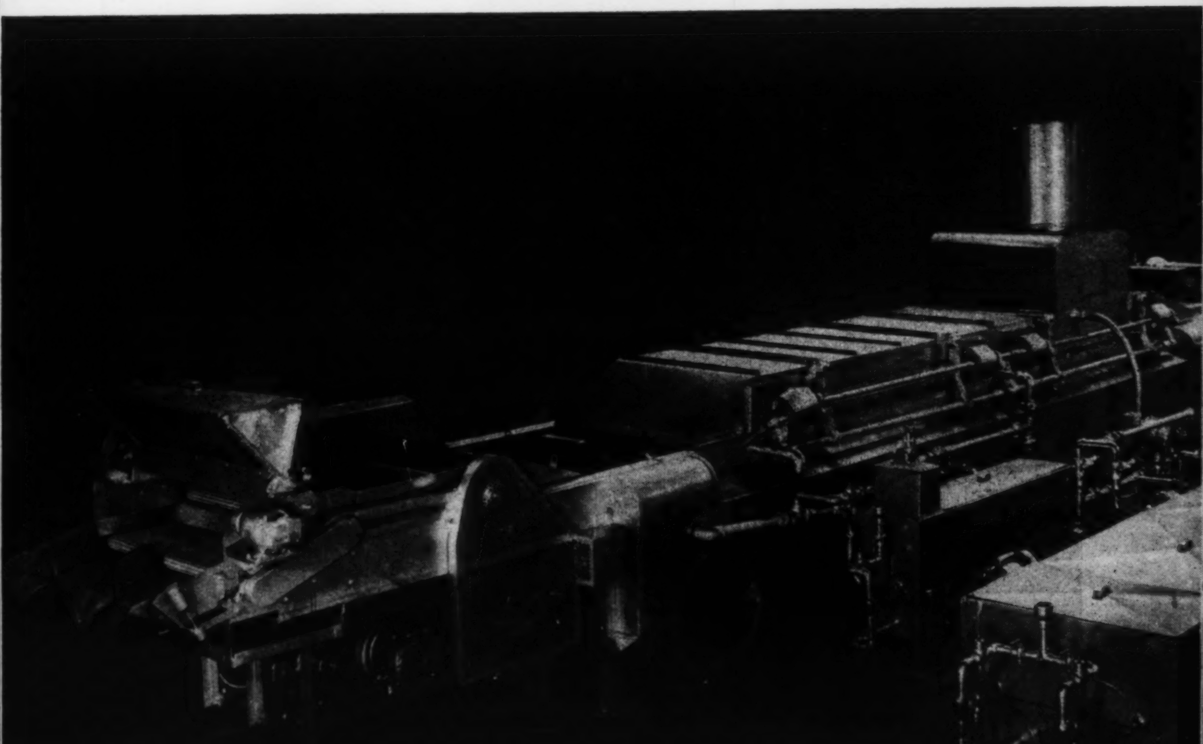
. . . an effective replacement for hard-to-get nickel-bearing stainless

Nickel-bearing stainless steel — popular but hard to get—seems destined to remain in short supply for an indefinite period, posing a serious problem in the selection of a practical substitute. One of the best solutions is this recommendation by AISI of a versatile alternate, readily available and with many of the same virtues.

tain differences in 17 per cent chromium stainless steel. The elongation value of type 302 is almost twice that of type 430. In the 17 per cent chromium grade, smaller spread between the tensile and yield strength, TABLE 1, reduces the range of plastic deformation. These differences between type 302 and

Fig. 1—Left—Conversion from nickel-bearing stainless to chrome stainless was accomplished without difficulty in this icing depositor of Mallet & Co. The outer shell, drawer, fixtures, top, hopper, drive cover, shaft and agitator are all fabricated of type 430 stainless

Fig. 2—Below—Potato-chip machine parts, switched from type 302 to 430, have proved so successful that J. D. Ferry Co. is planning permanent use of chrome stainless. Fabrication includes brake forming of plate, riveting, stamping, roll-forming and welding



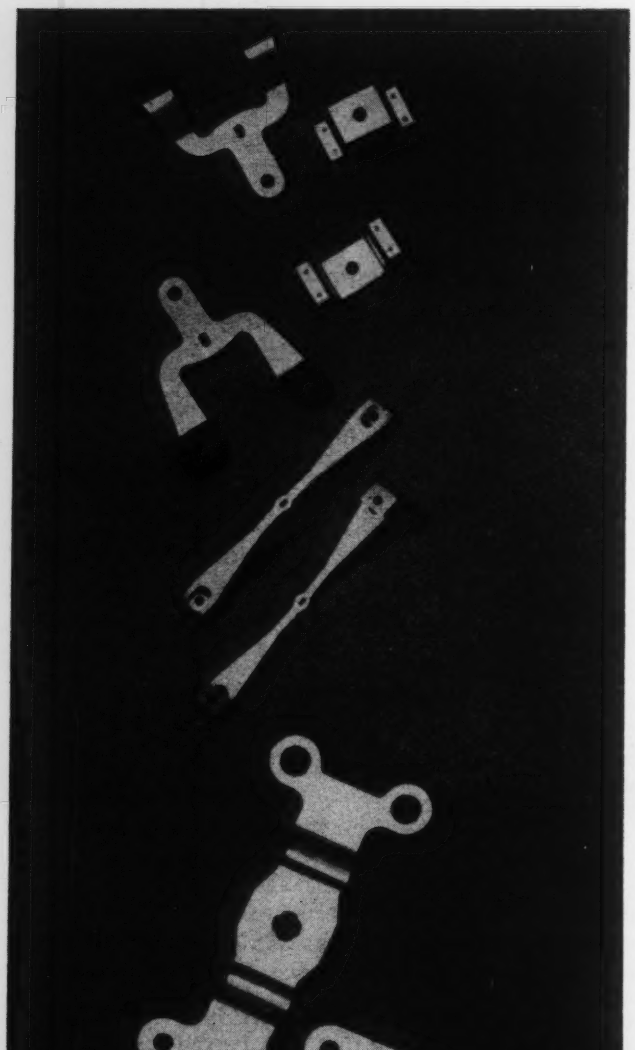


Fig. 3—Electrical control parts in the Sunbeam Mixmaster are stamped from thin 17 per cent chromium stainless. From top to bottom, the parts are: switch springs and control brackets, governor springs, control springs, catch plate, switch lever, center stud

type 430 make modifications necessary in some fabricating practices with type 430.

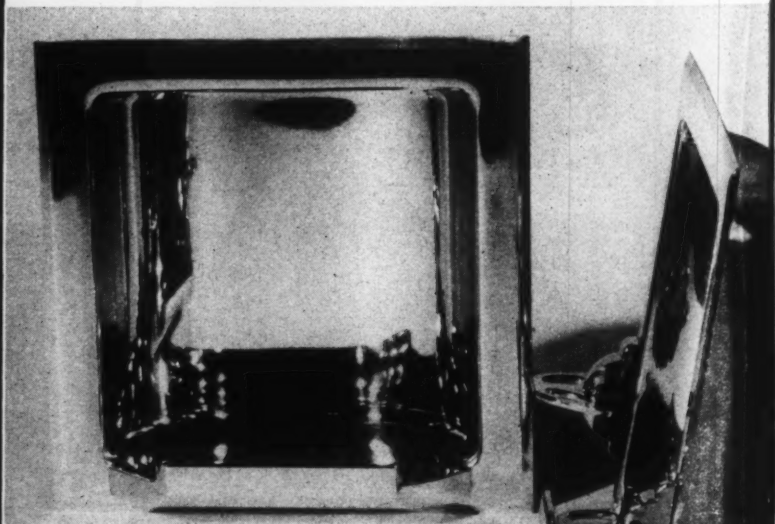
Equally important from the design standpoint, however, is the fact that, unlike type 302 stainless, type 430 and its variants do not work-harden to any considerable extent. This is a distinct advantage if the material is to be spun, but for drawing and forming operations presents certain difficulties.

Low Temperatures: Type 302, unlike most metals, remains ductile at extremely low temperatures. Type 430 and the other chromium stainless steels do not have this advantage. Slightly below room temperatures the fracture exhibited by type 430 changes from a ductile type to a brittle type. Therefore this grade is not recommended for low temperature use where impact resistance is a factor.

High Temperatures: Performance at high temperatures is much more favorable, TABLE 2. Type 430 has a high resistance to scaling and oxidation at high temperatures and resists destructive scaling up to 1550 F. Nevertheless, type 430 and its modifications do not have the high strength at elevated temperatures characteristic of the 18-8 stainless steels. Chromium stainless also has a tendency to become brittle at room temperatures after prolonged operation at temperatures in the 800-1000 F range. Slowly cooled equipment must be carefully handled at room temperatures. Ductility at operating temperatures is restored, however, on reheating.

Magnetic Properties: Unlike the 18-8 stainless steels,

Fig. 4—Bright, attractive mechanical finish that can be attained with type 430 is well shown by this bathroom fixture



the 17 per cent chromium types are magnetic. Depending on the exact analysis of the steel, annealed permeability may vary from 400 to 1900 compared to a 1.02 maximum for annealed type 302. Because of its magnetic properties, type 430 and its modifications should not be specified for applications where a nonmagnetic material is needed.

Welding Method: Type 430 stainless can be welded by any method except forge welding, but welded joints may be somewhat brittle at room temperatures. Annealing in the neighborhood of 1400-1500 F partly alleviates the brittle condition, Table 3. It will not correct grain growth, however, and the weld will therefore not be restored to the full ductility of the base metal.

The use of type 430T (sometimes referred to as type 430Ti) gives improved weld ductility, however, since the titanium contained in the grade inhibits the formation of martensite by welding heat. Type 430T welds are fairly ductile in both the as-welded and annealed conditions.

Inert gas shielded arc welding is often specified for sheet or very light plate since high welding speed is possible. An even more rapid type of welding is atomic-hydrogen arc welding. It is often used for making corner joints and edge welds in very thin sheets.

Table 2—High-Temperature Properties

Property	Type 430, 430T	Type 302
Maximum recommended temperature		
Continuous service (F)	1500	1600
Intermittent service (F)	1550	1450
Creep strength (1% elongation in 10,000 hr)		
At 1000 F (psi)	8500	17,000
At 1100 F (psi)	5000	12,000
At 1200 F (psi)	1300	7000
At 1300 F (psi)	1300	4000
Coefficient of thermal expansion		
32 to 212 F (10^{-6} deg F)	5.8	9.6
32 to 600 F (10^{-6} deg F)	6.1	9.9
32 to 1000 F (10^{-6} deg F)	6.3	10.2
32 to 1200 F (10^{-6} deg F)	6.6	10.4
32 to 1500 F (10^{-6} deg F)	6.9	....

But metal-arc welding is most widely called for in welding type 430 sheet. Metal-arc welding with a coated rod is handier with thicker pieces which need filler rod in addition to parent metal. Since the amount of heat at the joint is usually substantially less, for example, than with gas torch welding, the weld is more ductile. Resistance spot welding is also employed for the same reason.

As a rule, the oxyacetylene or gas torch welding process is not recommended for joining either type 430 or type 430T, since this method involves too much heating of the base metal near the weld with resulting grain growth in the weld zone.

Since coefficient of expansion of the 17 per cent chromium stainless steel is low, the problem of warpage during welding is not as great as with 18-8.

Weld Design: Weld joints should be placed at the least stressed parts of the weldment. Good design will avoid external or internal notches such as are found in corner joints or tee joints with incomplete penetration. On the other hand, a simple butt joint that shows full penetration presents the most desirable situation with regard to stress and impact. Such a joint can often be arranged with a little planning.

In general, either singe or double butt welds, with complete penetration, are first choice. Fillet welds are quite satisfactory. Corner welds are all right in some cases, but a flange and butt weld is more desirable than a lap or corner weld. Lap welds, either single or double, tend to localize stresses and are therefore not as effective.

As a general rule, all weld seams should be ground or machined until smooth, clean, and free of surface discontinuities. This prevents corrosion-sensitive crevices from forming. To minimize the possibility of crevice corrosion, the designer should eliminate joints with unfused notches or other discontinuities.

Brazing and Soldering: Brazing is a somewhat marginal method even with 302 because it involves relatively long periods in the sensitizing temperature range. Either copper brazing or silver brazing may be used with type 430, but silver brazed joints should not be exposed under water or in moist atmospheres. Actually, brazed joints are questionable for corrosive conditions with both types, since brazing temperatures induce greatest carbide precipitation. Soldering is in order for many uses, but solder should not be depended upon for mechanical strength.

Stamping: Shearing, blanking, coining and swaging operations present no particular problems in converting from type 302 to type 430 stainless.

The 17 per cent chromium stainless steels tend to show directional properties with reference to the direction in which the strip is rolled. A bend made parallel to this line in the course of longitudinal lock seaming may break. Therefore, the design should be planned so that most severe bends can be made across the strip rather than with it.

Ninety-degree bends on material 18 gage or lighter usually give no trouble, but if the radius is sharp, "orange peel" may show at the outside of the bend. This can be lessened by specifying an inside radius of at least one metal thickness.

On material lighter than 18 gage, 180-degree bends can usually be made if the bend is across the direction in which the strip is rolled. If the bend is parallel to the rolling direction, the inside radius of the bend should be at least one metal thickness. Material heavier than 18 gage requires a radius of at least two metal thicknesses on 180-degree bends if the bend is across the rolling direction and at least four if it is parallel to the rolling direction.

Drawing and Forming: Type 430 stainless steel can

Table 3—Fusion-Welded Joint Properties

Base Metal Type	Welding Process	Filler Metal Type	Test Condition	Tensile Strength	Elongation (% in 2 in.)	Fracture Location*	Guided Bend (deg)
430	Oxyacetylene	430	As welded	72,400	6.3	HAZ	15
			Annealed	68,200	7.0	HAZ	50
	Metal-arc	430	As welded	76,000	15.6	BM & WM	15
			Annealed	73,900	30.0	BM	180
		308	As welded	76,100	26.3	BM	85
	Inert-arc	430	As welded	74,000	26.6	BM	38
			Annealed	72,000	28.4	WM & BM	180
		308	As welded	74,400	23.6	BM	85-180
430T	Metal-arc	308	As welded	71,800	25.6	BM	180
	Inert-arc	None	As welded	70,700	25.0	WM	180

*HAZ—heat-affected zone; BM—base metal; WM—weld metal. Note: values are the results of specific spot tests, and are not necessarily the rule.

Table 4—Machinability

Type of Steel	Surface Speed (fpm, approx.)
Bessemer screw stock	165
Type 430F	120-150
Type 430	85-115
Type 302	40-85
Type 303	85-120

be drawn into deep, intricate shapes. The material draws about as well as the best quality deep drawing carbon steel and can actually be reduced as much as 20 to 25 per cent on the first draw; 15 per cent on subsequent draws. Even so, drawing practice may have to be modified, especially if conversion is made from type 302. Type 302 has unusually fine drawing properties and may be reduced as much as 35-40 per cent on the first draw. Thus in handling deep draws in type 430 stainless, an extra step is often added at the beginning of the operation. If possible, depth of draw should be held to an absolute minimum, and liberal radii should be used at the base and flange. These draw radii may even be double those customary for 18-8 stainless.

Spinning: The fact that type 430 does not work harden appreciably is a definite advantage in spinning operations. Quite often a "deep draw" can be made by first spinning material to rough shape, then drawing. Television viewing tubes are made in this fashion. Here a modified type 430 is used because its coefficient of expansion is the same as that of glass. To obtain the tube depth required the cone is first spun, then drawn to final shape.

Machining: Just as type 302 has its easy machining variant in type 303, so type 430 has such a variant in type 430F. Type 430F represents the best machining characteristics of the stainless steels, TABLE 4. It is being used quite successfully on automatic screw machines. Like type 430, type 430F cannot be hardened by heat treatment. It can be annealed to around 170 Brinell, but best machinability is obtained at approximately 228 Brinell.

Surface Finish: Type 430 and its modifications are not difficult to buff and polish. In fact in many cases the bright rolled finish of these alloys is quite satisfactory with only a superficial buffing. Since this particular finish is not available in type 302, finishing operations can actually prove more economical than with type 430.

Polished finishes obtained with an abrasive, however, may be a bit more expensive than those obtained with type 302. This will surely be true if the product has been severely formed; resultant stretcher strains and "ropiness" require extra grinding for their removal.

Even so, type 430 stainless steels develop a higher color than can be produced by the same amount of work on type 302. Fully polished, the surface resembles chrome plate. Electropolishing of type 430 stainless has proven practical on a number of kitchen accessories. Results, however, are not equal to the results obtained with type 302.

They Say . . .

"Up to 1940 large corporate investigators turned out a very small proportion of revolutionary improvements or outstanding inventions. Research was not yet considered as essential to a business since the competition was not so keen and the pace was not the dynamic surge of today. Independent investigators contributed ten times as many inventions as did organized research. Adjusted for number of workers and financial expenditure, the ratio might well be closer to a hundred to one.

"Since 1940, the ratio of productivity of private workers and 'corporate' investigators has changed and is continuing to change in favor of the group or team workers. The demands upon the modern individual and on the group inventors are vastly greater today. In order to produce inventions of value, there must be available to the inventor a background of knowledge of all phases of industry's problems for development or research. The inventor must have a more comprehensive education than formerly and above all, he needs a basic understanding of the fundamentals of all of the sciences with a good measure of mechanical skill and aptitude and mathematical knowledge and experience thrown in for good measure.

"Because of the increased complexity of modern science, technology and industry, it seems more and more unlikely that a lone, independent worker can come up with a great invention."—HAL F. FRUTH, *consultant and physicist, H. F. Fruth & Associates.*

Analyzing Beam Vibration

A simplified method for determining the natural frequency of uniform or nonuniform section beams

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IN VIBRATION analysis, the designer is frequently confronted with problems to which theory cannot be conveniently applied. A singular example is a beam of varying cross section; both area and moment of inertia vary along the length of the beam. For such beams, the critical frequency for the first mode of vibration cannot be easily determined.

Admittedly, a number of methods are available for solving this problem[1-5]; yet, all require somewhat laborious calculation or graphical manipulation. Thus, determination of the critical frequency has been a somewhat lengthy process, frequently prohibitive during the initial design stage. Presented in this article is a method of calculation which can be easily and conveniently applied and which is suitable for any type of loading.

Preliminary Considerations: To facilitate analysis, attention will first be devoted to a beam having an arbitrary transverse loading and a cross section which may vary in any manner. For this beam it can be shown that the inertia loading due to vibration will produce a bending moment resisted by internal beam forces. These internal and external moments must be determined. For convenience the beam will be assumed to be massless but under load; that is, the mass of the beam is lumped at some discrete number of points. The inertia load would then be the product of the mass and acceleration. The moment due to this inertia load would be the product of the force and the moment arm from the point of force application to the particular point along the beam where the moment is to be calculated. The internal resisting moment depends upon the material used, and is a function of the modulus of elasticity, the cross-sectional area of the beam as it enters into the moment of inertia determination and the curvature of the beam. This internal resisting moment is given by

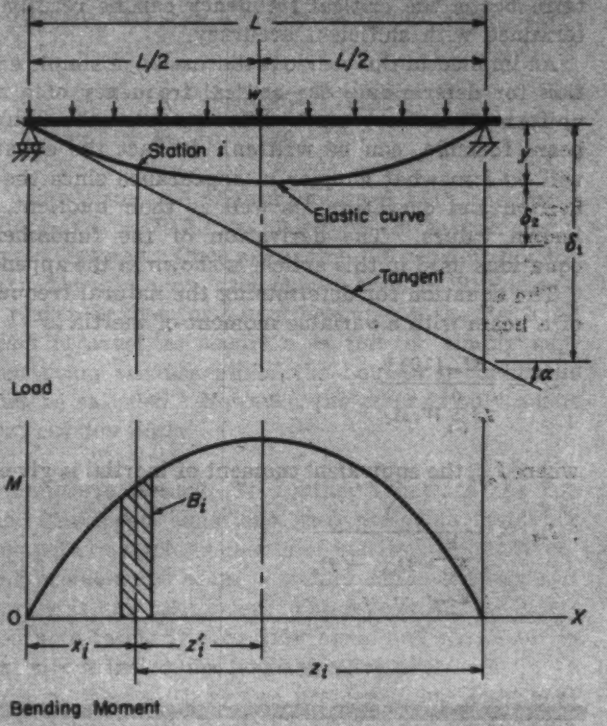

Fig. 1—Load and bending moment diagrams for derivation of basic beam curvature equations

$$M_{int} = EI \frac{d^2y}{dx^2}$$

where symbols are defined in the Nomenclature and *Fig.* 1.

Up to this point nothing has been stated as to the required uniformity of beam cross section or manner of load distribution. The solution of the problem requires that a summation be made along the length of the beam, introducing an additional complicating fac-

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[1] References are tabulated at end of article.

tor. If the moment of inertia is constant, this term can be factored from under the integration sign; however, if the moment of inertia varies with the length coordinate, x, it must remain under the integral sign.

Thus, if the moment of inertia is constant along the beam and both the deflection and curvature at any point are known, evaluation of the critical speed becomes relatively simple. Furthermore, for constant moment of inertia deflection and curvature values can be determined with sufficient accuracy, independent of the actual loads, to give an answer for the critical frequency which does not err by more than 7 per cent. Hence, if the beam with a variable moment of inertia can be replaced with an approximate *equivalent* uniform beam, the critical frequency can be readily determined with sufficient accuracy.

As implied in the previous discussion, a simple equation for determining the critical frequency of a nonuniform beam, not much different from the uniform beam formula, can be written. In fact the equation will be somewhat simpler in appearance since the deflection and curvature, as well as their quotient, are known values. The derivation of the fundamental equations used in this article is shown in the appendix.

The equation for determining the natural frequency of a beam with a variable moment of inertia is

$$\omega^2 = \frac{EI_{eq}(10)^4}{L^3 \sum_{i=1}^{Q} W_i A_i} \quad \text{.......... (1)}$$

where I_{eq}, the equivalent moment of inertia, is given by

$$I_{eq} = \frac{1}{\displaystyle\sum_{n=1}^{N} \frac{D_{n+1} - D_n}{I_n}} \quad \text{.......... (2)}$$

In Equation 1, the summation factor Q represents the total number of weights acting on the beam while in Equation 2, N is the total number of moment of inertia steps taken along the length of the beam.

The factor A_i may be determined from the chart in *Fig.* 2 for simply supported and cantilever beams. Its value is proportional to the quotient of deflection and curvature at the point where $x = x_i$. Values of D_n are given in the chart in *Fig.* 3 for simple and cantilever beams.

Equations 2 and 3 are particularly useful for analyzing nonuniform beams during the initial stages of design. From the maximum and minimum moment of inertia values, the frequency range within which the natural frequency of the beam must fall may be rapidly calculated. Using this range as an estimate, the designer can immediately foretell if resonance impends. If the calculated range does fall within a critical area, the equivalent moment of inertia may then be determined and an exact value for the frequency obtained.

Uniform Beam Examples: To establish the range of applicability of Equation 1, problems involving beams with constant moment of inertia will first be considered. In this way use of the equation can be illustrated and its accuracy tested.

PROBLEM 1: Determine the natural frequency of the

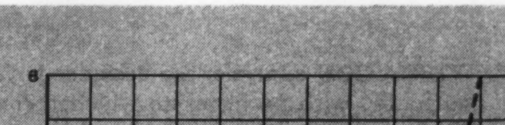


Fig. 2—Chart for determining values of A_i for simply supported and cantilever beams

Nomenclature

A = Chart factor for determining frequency of beam vibration
B = Area under bending moment curve
D = Chart factor for determining equivalent moment of inertia of beam
E = Modulus of elasticity of beam material, psi
f = Frequency of beam vibration, cps
g = Acceleration of gravity (386 inches per second^2)
i = Index number notation
I = Moment of inertia of beam cross section in bending, inches^4
L = Overall beam length, inches
M = Bending moment, pound-inches
m = Mass per unit length of beam, pound-second^2 per inch
n = Index number notation
W = Weight or force, pounds
w = Weight per unit length, pounds per foot
x = Abscissa of any beam station
y = Ordinate or deflection of any beam station
α = Slope of elastic curve, radians
ω = Angular frequency of beam vibration, radians per second
δ = Displacement of a point on the elastic curve from a line tangent to the curve at its origin

first or fundamental mode of vibration of a weightless shaft held between two flexible bearings and acted upon by forces as shown in *Fig.* 4. The moment of inertia is assumed constant along the shaft.

Since the moment of inertia is constant for this shaft, the equivalent and actual moments of inertia are the same. Therefore, only the factor A_i must be determined. Values for A_i can be found in *Fig.* 2 for the two points where the loads act; namely, at $x/L = 1/3$ and $x/L = 2/3$. These values, which are equal due to symmetry, have been compiled in the table in *Fig.* 4 in a suitable form for calculations. Substituting into Equation 1 gives

$$\omega^2 = \frac{EI(10)^4 g}{L^3(1.62\,W)g} = \frac{EI(10)^4 g}{L^3(1.62\,W)(386)}$$

or

$$\omega = 3.998\sqrt{\frac{EIg}{WL^3}} \text{ rad per sec}$$

For comparison, the answer obtained by the Rayleigh method[3] is

$$\omega = 3.989\sqrt{\frac{EIg}{WL^3}} \text{ rad per sec}$$

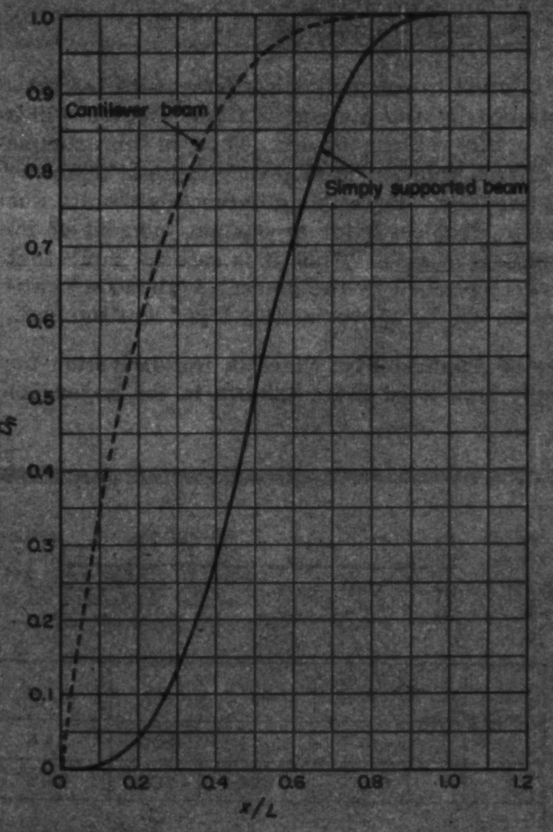


Fig. 3—Chart for determining values of D_n for simply supported and cantilever beams

The error involved is negligible and would be well within the accuracy limits required for most engineering calculations.

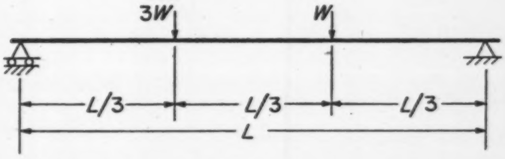
PROBLEM 2: Determine the natural frequency of a turbine blade which has a constant moment of inertia and is acted upon by stream forces as shown in *Fig.* 5. Blade material is steel, $E = 30 \times 10^6$ psi, and $I = 1$ in.[4]. As in Problem 1, only two values of A_i need be determined. The appropriate points in this case are $x/L = 0.6$ and $x/L = 1.0$. These values, taken from the curve in *Fig.* 2 for a cantilever beam, are listed in the table in *Fig.* 5 in the desired form. From Equation 1

$$f = \frac{\omega}{2\pi} = \frac{1}{2\pi}\sqrt{\frac{30(10)^6(1)(10)^4}{(10)^3\,1151}} = 81.5 \text{ cps}$$

For comparison the answer obtained with the Prohl method[2] is $f = 79.5$ cps. Also, by the matrix method, $f = 79.4$ cps. Once again the difference is not too great although more pronounced than in Problem 1. The reason is that for a cantilever beam the Rayleigh method is never as accurate as for the simply supported beam because all of the boundary conditions cannot be satisfied. However, the error is only about 3 per cent too high.

Nonuniform Beams: To further illustrate the use of the developed equations, two problems involving beams with variable moments of inertia will be solved. In one problem the beam is simply supported while in the other it is a cantilever. The former can be interpreted as a laterally vibrating beam and the latter is essentially a helicopter blade in vibration.

As a prelude to these two problems, one additional consideration should be pointed out. If a beam has a variable moment of inertia, it is always possible to find the least and the greatest moments of inertia for the beam. From these two moments of inertia the lowest and highest possible first mode frequencies for



i	x_i/L	A_i	W_i	$A_i\ W_i$
1	0.33	0.405	3W	1.215 W
2	0.67	0.405	W	0.405 W
				$\sum_{i=1}^{2} W_i\ A_i = 1.620W$

Fig. 4 — Load diagram and tabulated values for Problem 1

the given beam can then be determined, since the former corresponds to the weakest beam and the latter to the strongest obtainable for a given problem.

PROBLEM 3: The anticipated frequency range of operation for the shaft in *Fig.* 6 is from 115 to 150 cps. Is there a possibility of the shaft having a natural frequency in that range? Shaft material is steel, $E = 30 \times 10^6$ psi and $L = 22$ in.

A quick answer can be obtained by first assuming that the moment of inertia is constant and equal to the minimum value of 0.785 in.^{4} obtained at the 2-in. diameter section. Assembling applicable values from *Fig.* 2 in a suitable form as shown in *Fig.* 6 and employing Equation 1 in the frequency equation give

$$f = \frac{\omega}{2\pi} = \frac{1}{2\pi}\sqrt{\frac{30(10)^6(0.785)(10)^4}{(22)^3\,175.98}}$$

$$= 56.4 \text{ cps}$$

Then, by assuming the constant moment of inertia to have the maximum value of 3.98 in.^{4} obtained at the largest section and solving for the corresponding natural frequency,

$$f = \frac{\omega}{2\pi} = \frac{1}{2\pi}\sqrt{\frac{30(10)^6\,(3.98)\,(10)^4}{(22)^3\,175.98}}$$

$$= 125 \text{ cps}$$

The results of this rough approximation show that it is possible for the natural frequency to lie within the limits of operation. Therefore, a closer check on the frequency is necessary. However, it will be noted that if the frequencies had been below or above the range given, the problem would have been solved.

To check the frequency of the beam more accurately, *Fig.* 3 must be used. First, values of D_n are obtained for the beginning and end of each segment having a constant moment of inertia. Then, the difference between the values of D_n at the end and at the beginning of each segment are found. This step is necessary since each particular value of D_n is a sum of all D_n values up to the particular point selected. For this problem, values of D_n and I_n have been compiled in *Fig.* 6. From Equation 2,

$$I_{eq} = \frac{1}{\dfrac{0.032}{0.785} + \dfrac{0.363}{3.98} + \dfrac{0.605}{1.92}} = 2.22 \text{ in.}^4$$

Again employing the tabulated values of W_iA_i as well as the value obtained for I_{eq} and substituting Equation 1 into the frequency equation give

$$f = \frac{\omega}{2\pi} = \frac{1}{2\pi}\sqrt{\frac{30(10)^6\,(2.22)\,(10)^4}{(22)^3\,(175.98)}}$$

$$= 93.9 \text{ cps}$$

It will be noted that this value falls within the bracketing values calculated before and also is below the anticipated operating frequency range. For comparison the graphical solution would yield a value of $f = 99.2$ cycles/sec. Thus, calculation error is less than 3 per cent but is under the critical value. It has been found that for the simply supported beam the answer is usually below the exact answer—the more symmetrical the moment of inertia variation, the more accurate is the answer.

PROBLEM 4: Determine the natural frequency of the cantilever beam shown in *Fig.* 7. The variation of the mass and flexural rigidity EI as well as the values of A_i and D_n selected from *Figs.* 2 and 3 for the various x/L stations are tabulated in the figure. Again, upper and lower frequency values will be first obtained. Using $EI = 87.93 \times 10^6$ in Equation 1 gives

$$\omega_{max} = \sqrt{\frac{87.93(10)^{10}}{(259.4)^3\,(0.5198)\,386}} = 15.9 \text{ rad per sec}$$

Using $EI = 11.28 \times 10^6$ gives

$$\omega_{min} = \sqrt{\frac{11.28\,(10)^{10}}{(259.4)^3\,(0.5198)\,386}} = 5.7 \text{ rad per sec}$$

To evaluate the equivalent moment of inertia, a modified form of Equation 3 is used, giving

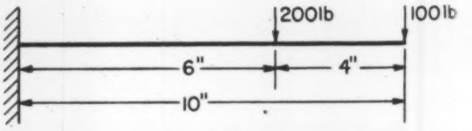
$$EI_{eq} = \frac{1}{\displaystyle\sum_{n=1}^{N} \frac{D_{n+1} - D_n}{EI_n}} = 30.2\,(10)^6$$

From Equation 1

$$\omega = \sqrt{\frac{30.2\,(10)^{10}}{(259.4)^3(0.5198)\,386}} = 9.3 \text{ rad per sec}$$

It is of interest to compare this answer with the solution obtained by the matrix iteration method which yields $\omega = 8.99$ radians per sec. Thus, in this example the calculated solution is slightly too high, again by about 3 per cent. The same difference in results was observed in Problem 2 for a constant moment of inertia cantilever beam. Thus, it is safe to imply that any answer obtained by the present method for cantilever beams will be approximately 3 per cent too high.

Range of Applicability: Since in the derivation for the simply supported beam (shown in the appendix)

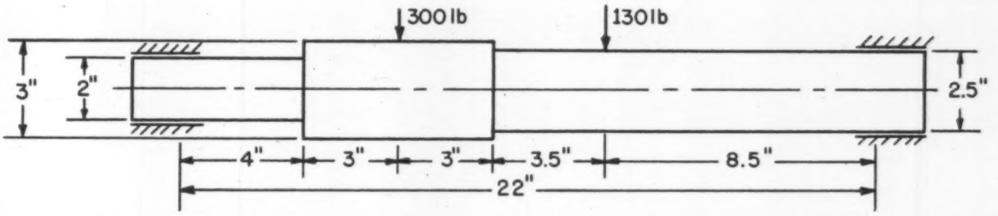


i	x_i/L	A_i	W_i	$A_i\ W_i$
1	0.6	1.73	200	346
2	1.0	8.05	100	805
				$\sum_{i=1}^{2} W_i\,A_i = 1151$

Fig. 5 — Load diagram and tabulated values for Problem 2

the deflections of the uniform and nonuniform beam are equated at the center point, the more nearly symmetrical the loading and moment of inertia distribution the more accurate the answer. If the asymmetry of loads and moment of inertia variation should fall on the same side of the midpoint, the effect on the results obtained would be particularly adverse. For the cantilever beam, since the deflections have been equated at the free end, high loads at a very thin section at the free end would cause the results to be in error. However, in practice these conditions do not often occur. For the usual types of mass concentrations encountered the results will be accurate within the ranges previously stated.

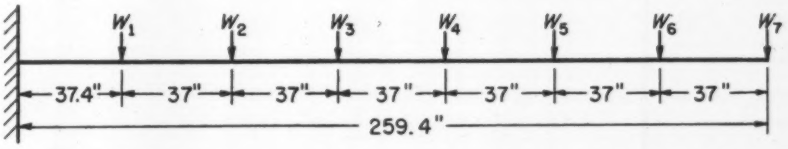
Appendix: The quantities A_i and D_n employed in the article for the solution of critical beam frequencies



i	x_i/L	A_i	W_i	$A_i\ W_i$
1	0.318	0.376	300	112.80
2	0.600	0.486	130	63.18
				$\sum_{i=1}^{2} W_i A_i = 175.98$

n	x_n/L	D_n	$D_{n+1}-D_n$	I_n
1	0	0		
			0.032	0.785
2	0.182	0.032		
			0.363	3.980
3	0.455	0.395		
			0.605	1.920
4	1.00	1.00		

Fig. 6 — Load diagram and tabulated values for Problem 3



i or n	$\frac{x_i}{L}$	$\frac{W_i}{g}$	A_i	$\frac{W_i\ A_i}{g}$	D_n	$D_{n+1}-D_n$	$EI \times 10^{-6}$	$\frac{D_{n+1}-D_n}{EI_n}$
0	0	0	0	0	0			
						0.460	87.93	0.00524
1	0.144	0.167	0.027	0.00451	0.460			
						0.280	28.97	0.00968
2	0.287	0.0400	0.090	0.00360	0.740			
						0.155	16.10	0.00953
3	0.429	0.0340	0.510	0.01730	0.895			
						0.071	12.33	0.00575
4	0.572	0.0291	1.410	0.04100	0.966			
						0.028	11.28	0.00248
5	0.715	0.0292	3.000	0.08760	0.994			
						0.004	11.28	0.000355
6	0.860	0.0308	5.325	0.16380	0.998			
						0.002	11.28	0.000177
7	1.000	0.0251	8.050	0.20200	1.000			
				$\sum_{i=1}^{7} \frac{W_i A_i}{g} = 0.51981$				$\sum_{n=1}^{8} \frac{D_{n+1} D_n}{EI_n} = 0.033212$

Fig. 7—Load diagram and tabulated values for Problem 4

have been derived from the basic beam vibration equations. The fundamental form of Equation 1 would be

$$\omega^2 = \frac{\int_0^L EI\left(\frac{d^2y}{dx^2}\right)^2 dx}{\int_0^L m\, y^2\, dx} \qquad (3)$$

where m is the mass per unit length, or

$$\omega^2 = \frac{\sum_{i=1}^{Q} EI\left(\frac{d^2y_i}{dx^2}\right)^2 \Delta x}{\sum_{i=1}^{Q} \frac{W_i}{g} y_i^2} \qquad (4)$$

For the simply-supported beam a power series expansion can be obtained for the deflection which will satisfy the boundary conditions at the ends. Such a series would be of the form, if taken to x^8 term only,

$$y = \frac{L^8}{720(56)}\left[\left(\frac{x}{L}\right)^8 - 4\left(\frac{x}{L}\right)^7 + 14\left(\frac{x}{L}\right)^5 - 28\left(\frac{x}{L}\right)^3 + 17\left(\frac{x}{L}\right)\right] \qquad (5)$$

Then, by differentiation,

$$\frac{d^2y}{dx^2} = \frac{L^6}{720}\left[\left(\frac{x}{L}\right)^6 - 3\left(\frac{x}{L}\right)^5 + \left(\frac{x}{L}\right)^3 - 3\left(\frac{x}{L}\right)\right] \qquad (6)$$

If EI is constant, then

$$\omega^2 = \frac{EI}{\sum_{i=1}^{Q} W_i \left[\frac{\frac{y_i^2}{g}}{\sum_{i=1}^{Q}\left(\frac{d^2y_i}{dx^2}\right)^2 \Delta x}\right]} \qquad (7)$$

Thus, let

$$\frac{L^3 A_i}{10^4} = \frac{\frac{y_i^2}{g}}{\sum_{i=1}^{Q}\left(\frac{d^2y_i}{dx^2}\right)^2 \Delta x} \qquad (8)$$

This term can be evaluated with the help of Equations 5 and 6. The results are plotted in *Fig.* 2.

A similar power series expansion can also be used for the cantilever beam. These final results have also been plotted in *Fig.* 2.

The equivalent moment of inertia equation was obtained upon the premise that a uniformly loaded beam is used for comparative purposes. First, a uniformly loaded simply supported beam was considered. Assuming the moment of inertia to be constant and using the moment-area method permit finding of the deflection at the midpoint. Next, the moment of inertia was allowed to vary in a step-wise fashion. The deflection for the midpoint was again obtained by the moment-area method. The deflection at the midpoint of the uniform beam was then equated to the deflection at the midpoint of the nonuniform beam and the equivalent uniform moment of inertia was found. The point where the two deflections are forced to be equal is an arbitrary selection only with theoretical indications used as a guide. The numerical examples seem to justify the choice.

In equation form, at $x = L/2$, $y = y'$ where y is the uniform beam deflection, and y' is nonuniform beam deflection. Also

$$\delta = \int \frac{1}{EI} Mz\, dz \qquad (9)$$

from the area-moment theorem where z is the abscissa of any beam station measured from an origin at the right-hand end of the beam. Applying this equation in summation form to the uniformly loaded beam gives, for $x = L/2$ or $z' = 0$, where z' is the abscissa of any beam station measured from an origin at $x = L/2$,

$$y = \frac{1}{EI_{eq}}\left[\sum_{i=1}^{r} \frac{B_i z_i}{2} - \sum_{i=1}^{s} B_i z_i'\right] \qquad (10)$$

and

$$y' = \frac{1}{E}\left[\sum_{i=1}^{r} \frac{B_i z_i}{2 I_i} - \sum_{i=1}^{s} \frac{B_i z_i'}{I_i}\right] \qquad (11)$$

where

$$y = \frac{\delta_1}{2} - \delta_2 \qquad (12)$$

The summation factor r represents the total number of areas B_i taken from $x = 0$ to $x = L$ and s represents the total number of areas B_i taken from $x = 0$ to $x = L/2$.

Thus, since $y = y'$ at $x = L/2$,

$$I_{eq} = \frac{\sum_{i=1}^{r} \frac{B_i z_i}{2} - \sum_{i=1}^{s} B_i z_i'}{\sum_{i=1}^{r} \frac{B_i z_i}{2 I_i} - \sum_{i=1}^{s} \frac{B_i z_i'}{I_i}} \qquad (13)$$

The physical terms are shown in *Fig.* 1.

For the uniformly loaded beam the numerator of Equation 13 can readily be evaluated and then Equation 3 is obtained, where D_n has been evaluated in *Fig.* 3. Similar procedures also apply for the cantilever beam.

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Continuous-Cast Shapes

. . . offer economies in the design of copper-alloy parts

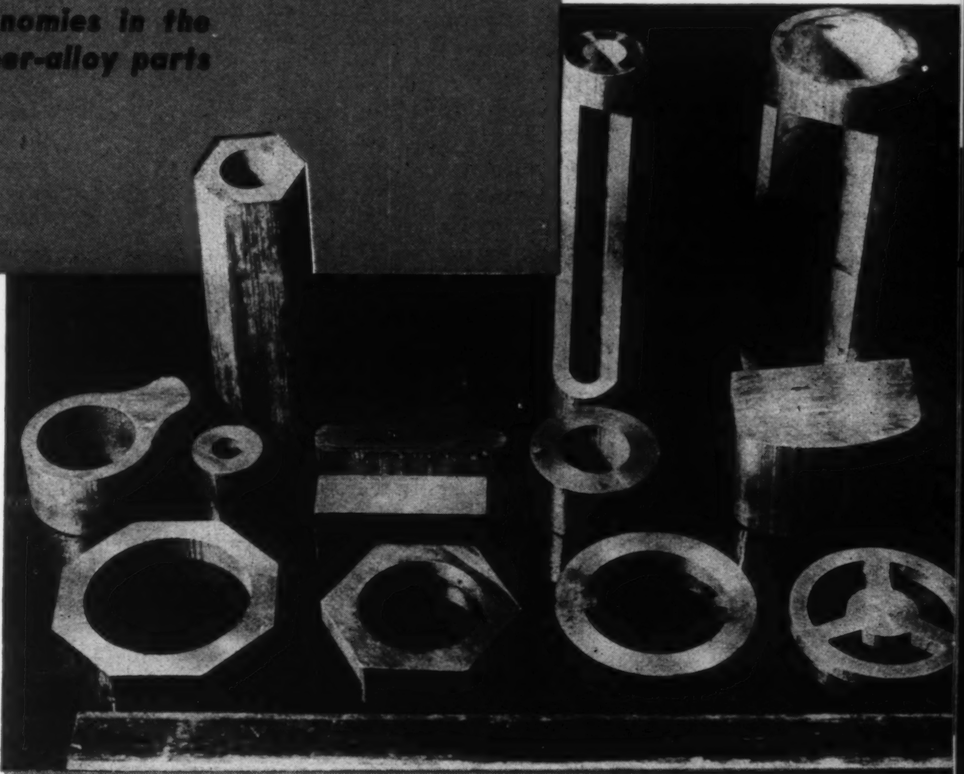
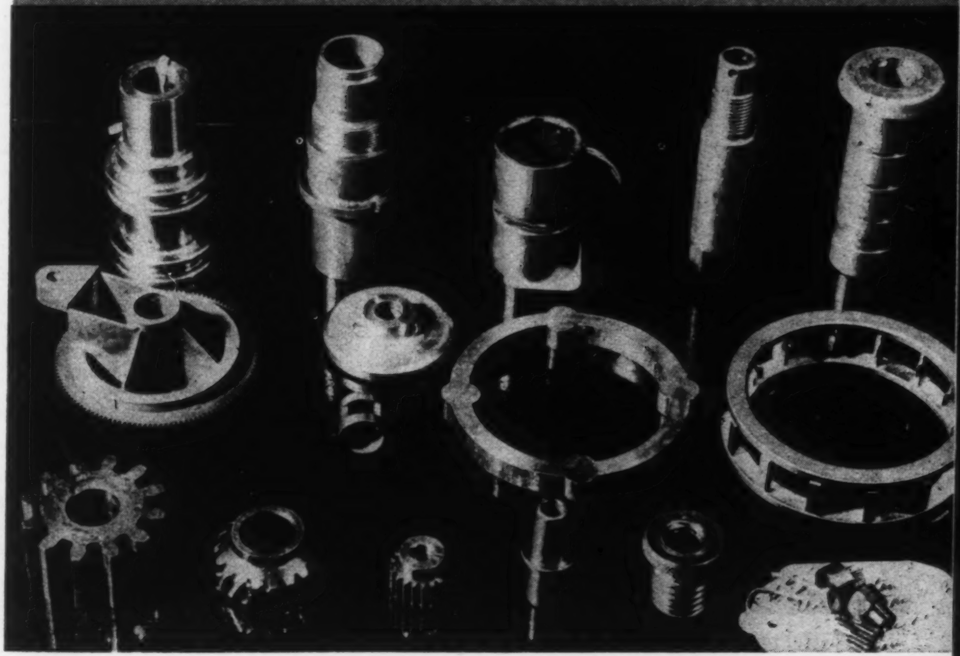


Fig. 1—Above—Typical shapes produced by continuous casting of copper-base alloys

Fig. 2—Below—From the shapes shown in *Fig.* 1, parts and subassemblies can be produced with minimum scrap loss



CONTINUOUS shapes, either extruded or cast, offer many design opportunities for parts that are completely or partially symmetrical along one axis. Gears, bushings, shafts, valves, nuts and studs can be economically produced since cast shapes approach the finished contours, *Fig.* 1. Thus scrap loss is reduced, and machining and overall costs are lowered.

A new process for continuous casting of copper alloys in shapes, rods or tubes extends the range of usefulness of this method. Continuous casting is not new, but heretofore has been restricted to the production of billets, bars or slab for manufacturing strip, rod, tubing, etc., by usual brass-mill operations. The new process of American Smelting & Refining Co., however, is now in commercial use, producing leaded or nonleaded bronze alloy stock ready for machining or other fabricating operations.

Parts produced by the exclusive Asarco casting process must be symmetrical or nearly so. Unusual shapes can be cast, *Fig.* 2, including internal and external projections, webbed stock, square rod, and square tube with a circular hole. Lengths of 12 feet are standard, although any lengths to 20 feet can be obtained. Outside diameters range from $\frac{7}{16}$ to $5\frac{1}{8}$ inches.

With respect to dimensional accuracy, tolerances on outside diameter of rod and tube are +0.004,

-0.006-inch. Straightness is held to ¼-inch maximum arc depth in a 5-foot length, and concentricity is 1½ per cent of wall thickness. Recommended cleanup allowances are $\frac{1}{16}$-inch on outside diameter and $\frac{1}{32}$-inch on inside diameter; for many alloys and sizes, however, $\frac{1}{32}$-inch on the outside diameter is sufficient.

Low, medium and high-leaded bronzes can be produced, TABLE 1; some high-leaded alloy rod, that cannot be turned out as a wrought product, can be cast by the process. Strength properties, including fatigue and impact strengths, are inherently favored by the process, which excludes such flaws as blowholes, impurities and porosity. Continuously cast metal shows a coarse lateral chevron macrostructure, because of the horizontal freeze in the casting process, and an extremely fine microstructure with uniform grain size.

In the casting operation *Fig.* 3, an alloy starting tip extends through a die into the molten metal at the bottom of a crucible. As the starting tip is extracted, molten metal flows by gravity into the die and is immediately frozen by the water jacket. Since the metal is frozen from the bottom upward, escape of dissolved gases liberated during solidification is permitted. The molten bath serves as both riser and head, preventing the formation of shrinkage cavities. Baffling of the crucible prevents turbulence, and keeps dirt and dross floating on top of the molten metal, isolated from the casting.

Table 1—Typical Properties of Continuous-Cast Copper Alloys

SAE No.	Nominal Composition (%) Cu	Sn	Pb	Zn	Tensile Strength (psi)	Yield Strength (psi)	Elongation (% in 2 in.)	Reduction in Area (%)	Hardness (brinell)	Impact Strength* (ft-lb)
65	89	11	..	..	51,000	29,000	18	..	100	..
63	88	10	2	..	49,000	25,000	18	..	86	..
62	88	10	..	2	51,000	28,000	18	11	92	25.5
620	88	8	..	4	49,000	23,000	18	..	77	..
622	88	6	1.5	4.5	45,500	23,000	35	..	76	..
66	85	5	9	1	38,000	21,000	20	..	66	..
40	85	5	5	5	45,000	21,400	28	21	72	20.7
660	83	7	7	3	44,000	27,000	16	14	72	12.5
64	80	10	10	..	41,000	26,000	10	..	80	..
	80	2.5	10	7.5	34,000	18,000	22	..	62	..
..	75	5	20	..	28,700	22,800	8	7	57	6.2

*ASTM E23-41T, Type Z.

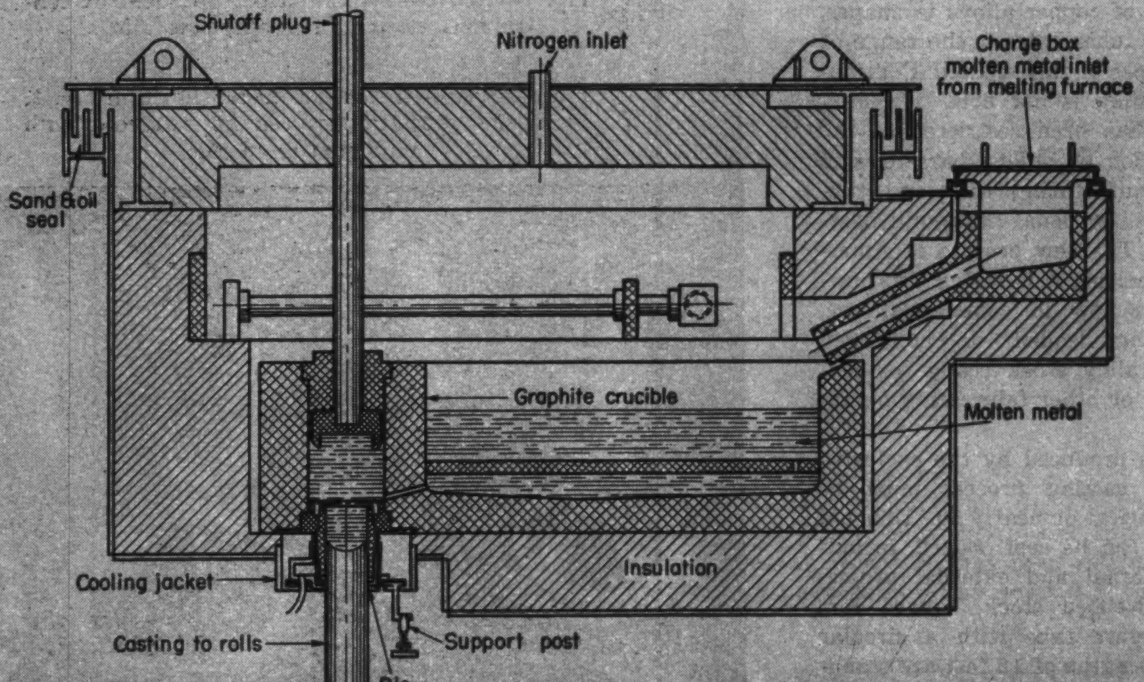
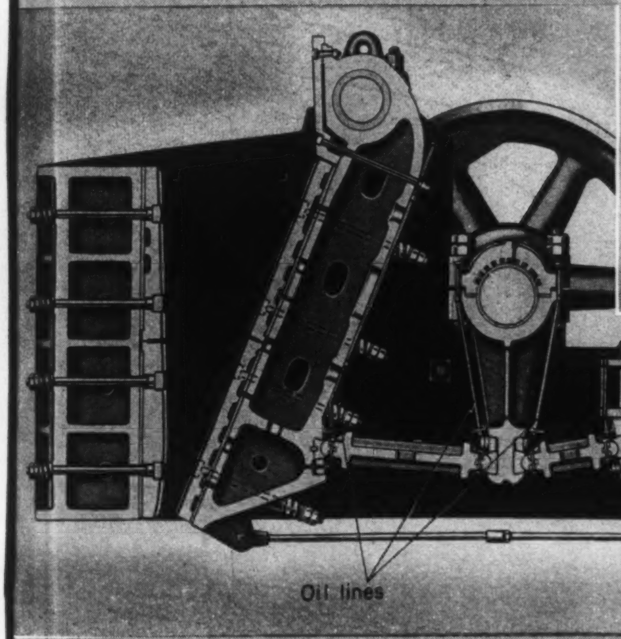


Fig. 3—Crucible and die arrangement for continuous casting. The casting is drawn out at controlled speeds from graphite dies in which it solidifies

Fig. 1—Below—Cross-section of a jaw crusher having toggle ends and bearings of type patented in 1880. Oil lines deliver lubricant to bearings



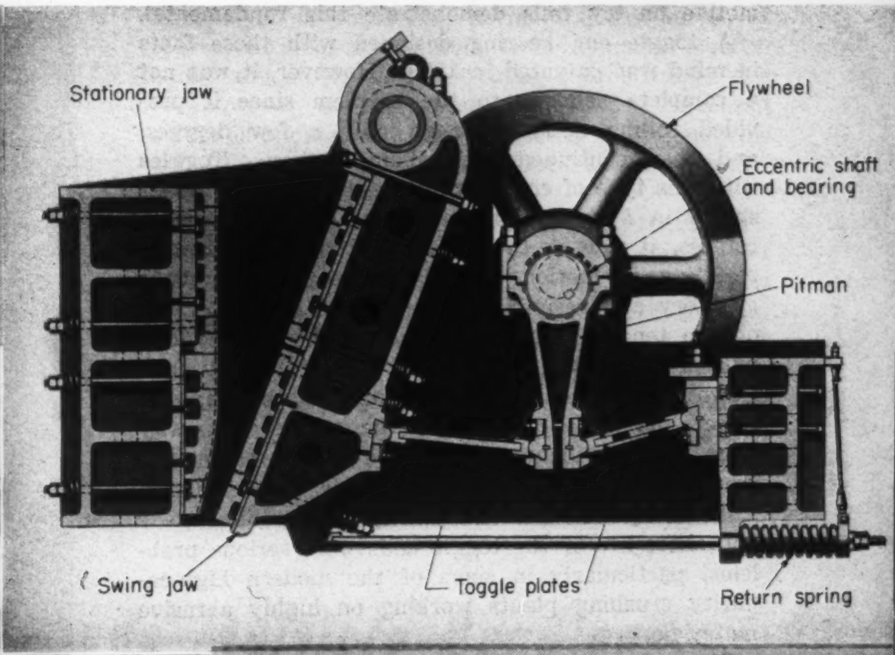


Fig. 2—Above—Cross-section of crusher using toggle ends and bearings having rolling contact. Curvature of contacting surfaces is reverse of that previously used

DRY ROLLING BEARINGS

. . . for heavy-duty toggle mechanisms provide long life and require no lubrication

By A. J. Roubal *Engineer in Charge of Development, Processing Machinery Dept., Allis-Chalmers Mfg. Co., Milwaukee, Wis.*

TOGGLE mechanisms have long been used because of their high mechanical advantage. In fact, a patent was granted in 1858 to Eli Whitney Blake covering a jaw crusher using a toggle mechanism to produce the required high force. However, the large force developed by the toggle mechanism was also a contributing factor to the rapid wear and galling of the toggle ends and seats. Attempted lubrication failed to reduce wear because of the extreme pressures and the short-arc oscillatory action of the toggles.

As early as 1880 it was recognized that rolling contact instead of sliding contact at the toggle ends would alleviate this problem. True rolling action between two contacting surfaces requires no lubrication. Actually no lubricant should be used; the coefficient of sliding friction should be as high as possible. A rocking chair on a greased floor or a locomotive on icy rails demonstrate this fundamental.

A toggle end bearing designed with these facts in mind was patented in 1880. However, it was not a complete solution to the problem since it provided rolling action through only a few degrees, and then continued with sliding action. Toggles with this type of end bearing are used in the crusher shown in *Fig.* 1. As the flywheel of the crusher rotates, it causes the eccentric bearing to rotate, resulting in motion of the pitman which is both gyratory and reciprocating. Upward motion of the pitman tends to straighten the toggle plates which pushes the swing jaw toward the stationary jaw. Downward motion of the pitman has the opposite effect and the spring pulls the swing jaw away from the stationary jaw. The average pressure transmitted through the toggles is approximately 1,500,000 pounds. Consequently the galling, wear and short life of the toggle ends were serious problems, particularly in some of the modern high-capacity crushing plants working on highly abrasive materials.

The solution of this problem is the dry rolling toggle used on the crusher shown in *Fig.* 2. A new concept was applied in the development of this toggle and bearing. The curvature of mating toggle ends and seats was simply reversed. Toggle plate ends became concave instead of convex and the mating seats became convex instead of concave. An analysis of the operation of the dry rolling toggle during a complete crushing cycle, *Fig.* 3, shows that the line of force is within the toggle plate at all

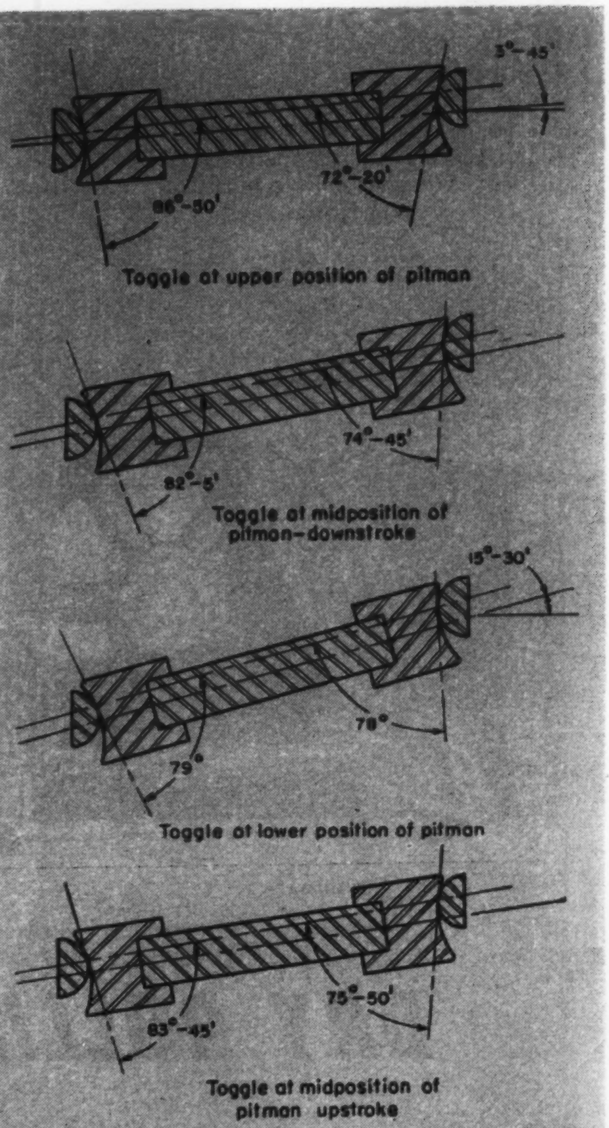
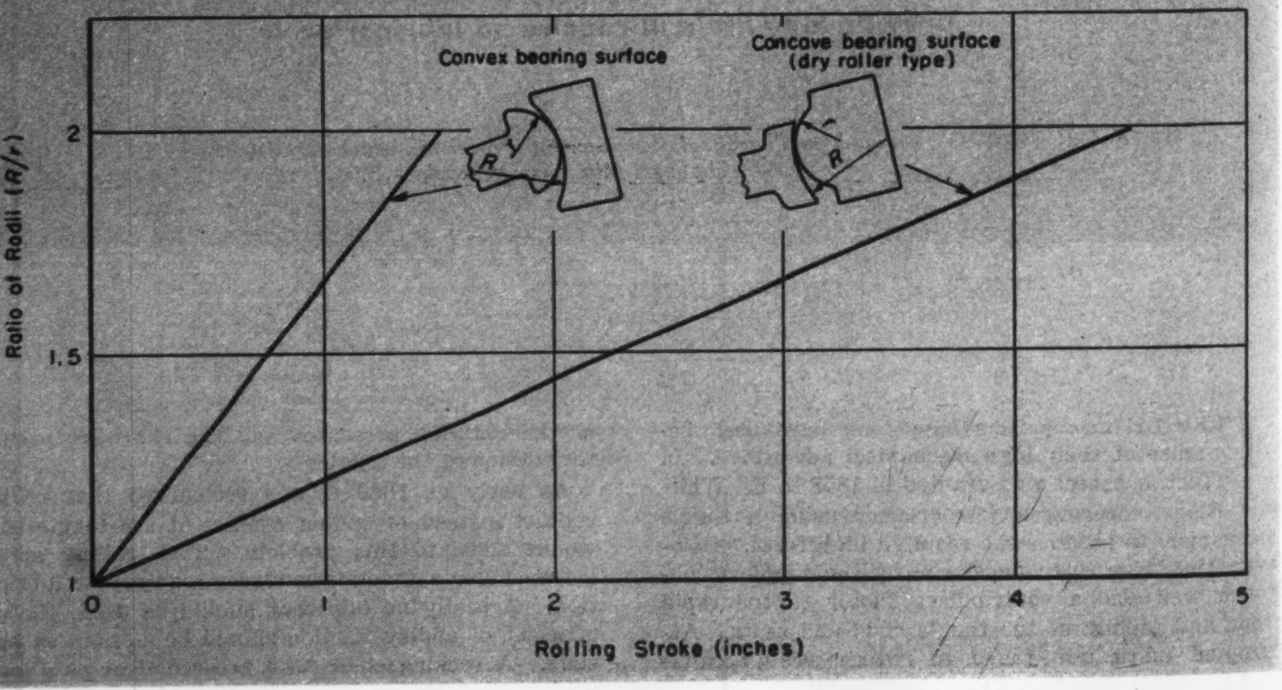

3°-45'
72°-20'
86°-50'
Toggle at upper position of pitman
74°-45'
82°-5'
Toggle at midposition of pitman-downstroke
15°-30'
78°
79°
Toggle at lower position of pitman
75°-50'
83°-45'
Toggle at midposition of pitman upstroke

Fig. 3 — Right — Sequence of toggle positions during entire crushing cycle

Fig. 4—Below—Comparison of dry rolling and conventional toggle characteristics



times. This requirement was not satisfied by the earlier design.

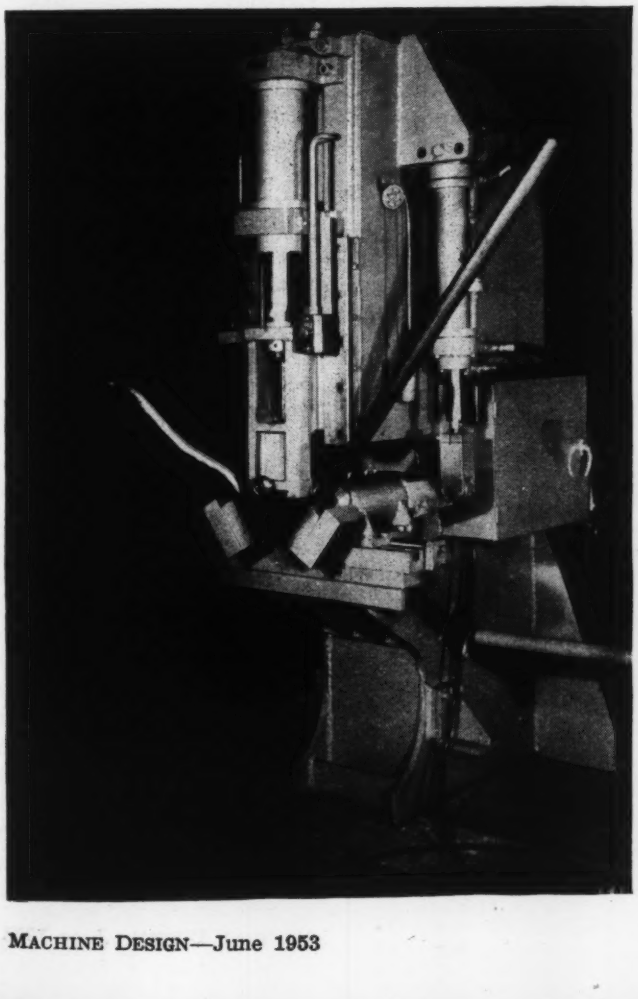
The differences in performance between the dry rolling toggle and the type patented in 1880 are shown in *Fig.* 4. Data for this graph were obtained with a model having a variable-throw eccentric shaft driven by a variable-speed motor. Various ratios of toggle ends and seats were used and the maximum throw at which rolling stopped and slippage occurred was plotted for each ratio. Note that a 2 to 1 ratio toggle bearing of the previous type rolled through a maximum stroke of 1½ inches, whereas the same ratio in the dry rolling type rolled through a maximum stroke of 4½ inches.

The advent of the dry rolling toggle with its high coefficient of friction and rolling action reduced wear because rolling action by its very nature causes least wear on contacting parts. Lubrication is, of course, no longer required, thus reducing maintenance and eliminating the possibility of failure due to improper or infrequent lubrication. Increased safety is another advantage since oil no longer drips into the crusher pit to cause precarious footing for maintenance workers.

Operational experience with the rolling toggle ends has shown life increases from 4 to 32 months and in another case from 8 to 24 months, with no signs of wear and indefinite life expectancy at the end of these lengthened periods of service. Another proof of the reduction of friction and wear resulting with true rolling action is that with pressures of 1,500,000 pounds or more the toggle ends and seats are cold even after 16 hours of continuous operation under adverse conditions.

Vertical Press Speeds Multiple Bending

VERTICAL design of a recently developed pipe and tube bending press results in unusually large working clearances which permit multiple bending in various planes. The large working clearance allows bending a two-inch tube with a five-inch centerline radius to 180 degrees. One of the primary applications of the press, manufactured by Pines Engineering Co. Inc., is in the production of automotive exhaust and tail pipes.



Cushion cylinders mounted outside the working area exert from ½ to 15 tons of force through heavy crank arms to the wing dies. Three anchor positions of the cylinders permit various die-holder settings. A single adjusting screw controls both die settings. Heavy alloy spindles of the crank arms are mounted in needle bearings to assure smooth operation and help eliminate diminishing pressures on deep bends. Positive equalizing action of the die-cushion design assures accurate wing die adjustment and prevents flat bends.

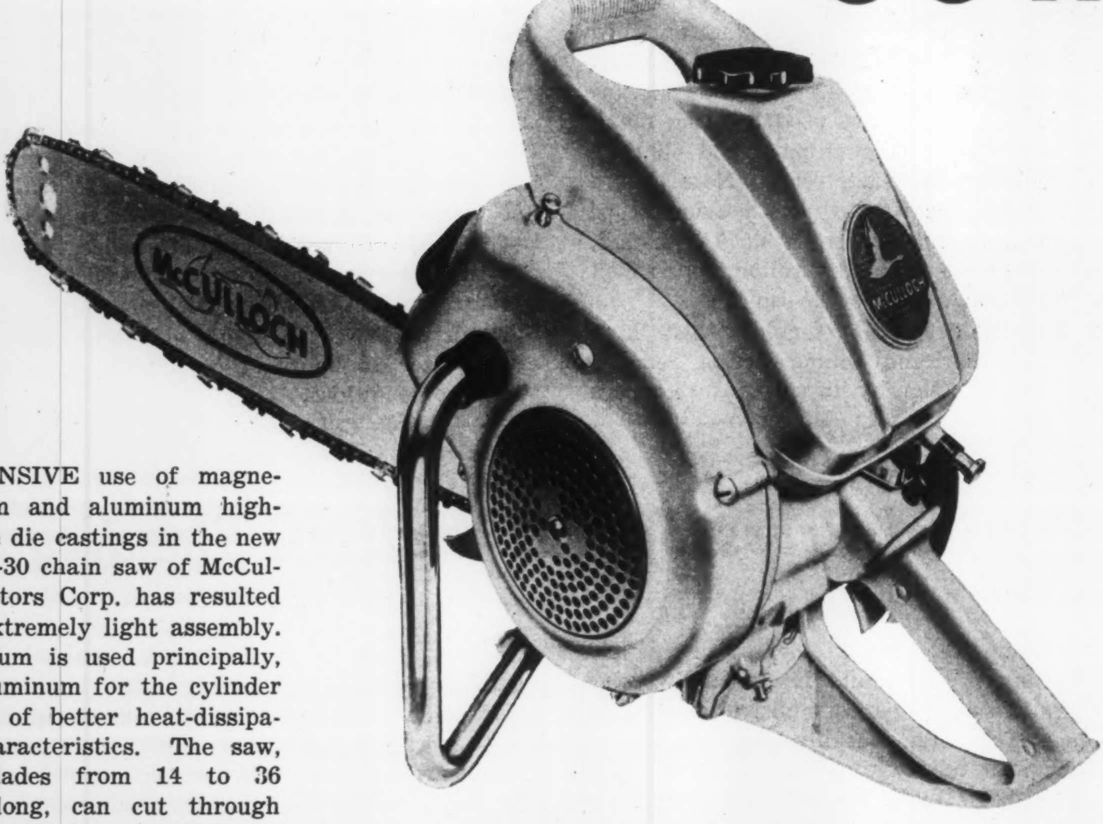
A ten-station depth-of-bend selector turret mounted on the press frame controls bend depth automatically. After any preselected number of bends from one to ten is completed, the turret automatically returns to the starting position, eliminating cycling through unused positions. Interchangeable preset turrets for the depth-of-bend selector can be stored and quickly remounted for repetitive jobs. This feature reduces setup time and assures accurate duplication of previous work. Setups are further simplified by a separate hydraulic control valve which permits the vertical ram to be lowered to fit a given sample and stopped in that position while depth-of-bend turret screws are adjusted to duplicate the sample.

The press has a rated capacity of 20 tons, and is fully hydraulic and self-contained. A 100-gallon oil reservoir is built into the machine base. The 20-horsepower motor is vertically mounted at the rear.

They Say . . .

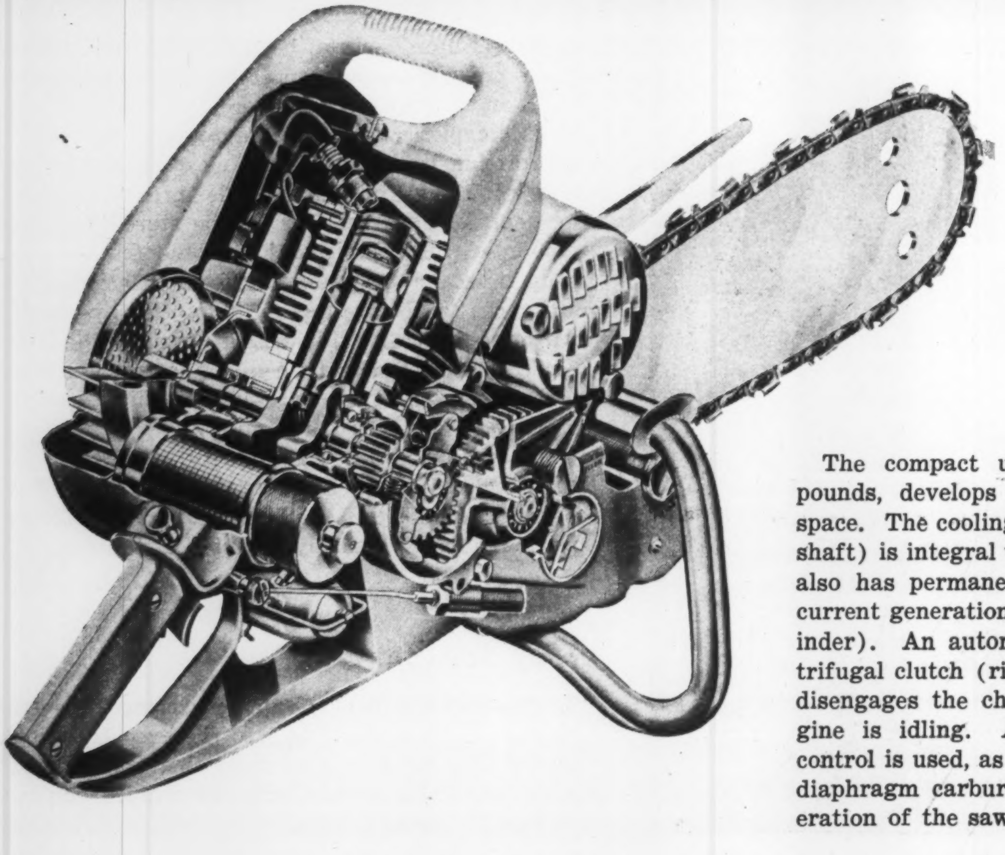
"In the gigantic field of applied science, the trained engineer is now emerging into the executive field. It is said that the heads of more than one-half of the great productive corporations are trained engineers." —HERBERT HOOVER.

CONTE



EXTENSIVE use of magnesium and aluminum high-pressure die castings in the new model 4-30 chain saw of McCulloch Motors Corp. has resulted in an extremely light assembly. Magnesium is used principally, with aluminum for the cylinder because of better heat-dissipation characteristics. The saw, with blades from 14 to 36 inches long, can cut through timber up to 5 feet in diameter.

Engine-Driven Saw Weighs Only 30 Pounds

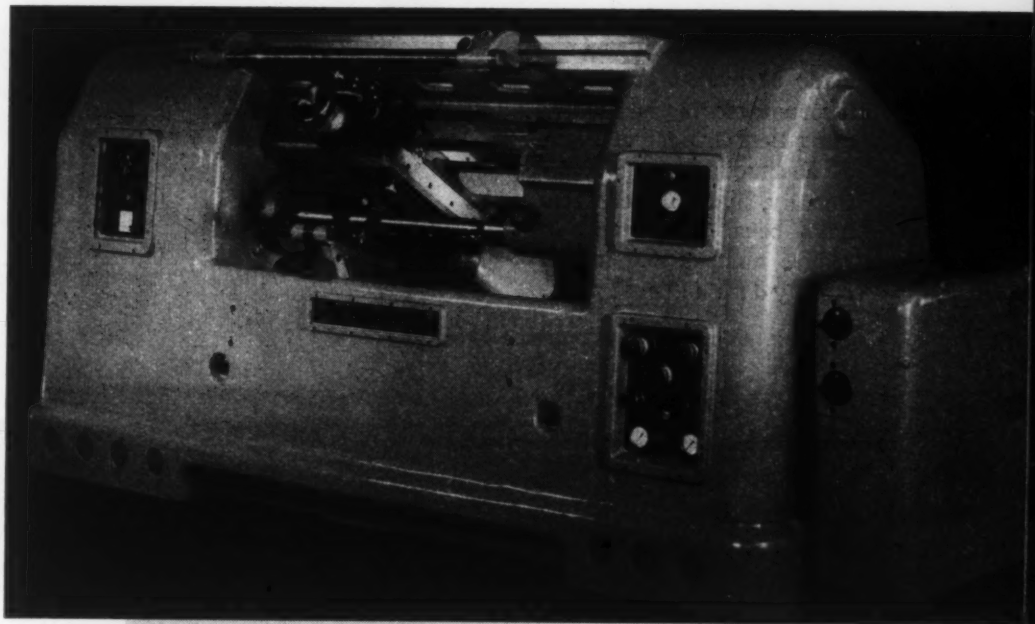


The compact unit, weighing only 30 pounds, develops ample power in small space. The cooling fan (left end of crankshaft) is integral with the flywheel, which also has permanent magnets cast in for current generation in the coil (left of cylinder). An automatic wedge-action centrifugal clutch (right end of crankshaft), disengages the chain drive when the engine is idling. A trigger-type throttle control is used, as well as an aircraft-type diaphragm carburetor which permits operation of the saw in any position.

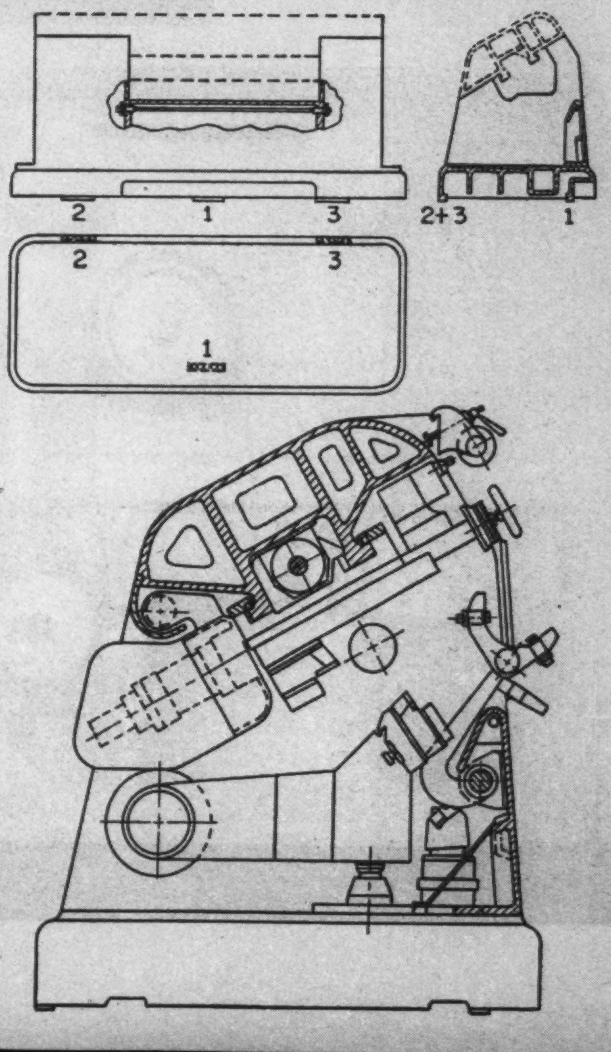
EMPORARY DESIGN

Upside-Down Bed on Copying Lathe

SEVERAL unusual design features are incorporated into a copying lathe developed by Heidenreich & Harbeck, Hamburg, Germany—among them an upside-down bed that facilitates chip flow and protects the guides against damage from cuttings. Eighteen spindle speeds from 28 to 1800 rpm can be preselected hydraulically when the spindle is stopped. A maximum of 40 horsepower is transmitted through a special flat belt.



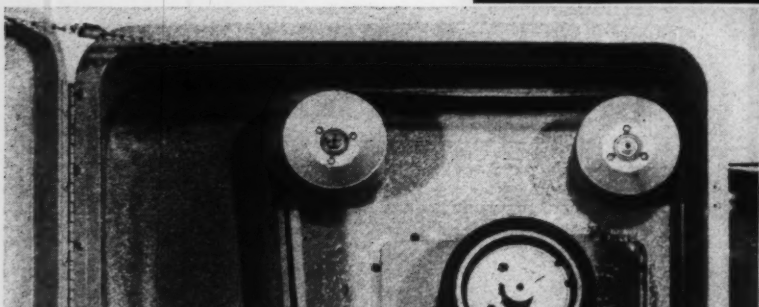
Three-point support of the base eliminates the need for a special foundation and makes the lathe relatively insensitive to externally excited vibration. The exceptionally wide base support, with a low center of gravity near the workpiece, also helps in this respect. Particular rigidity is given to the whole base by a drawbar which is assembled and tightened while hot, thus producing a prestress of 30 tons.



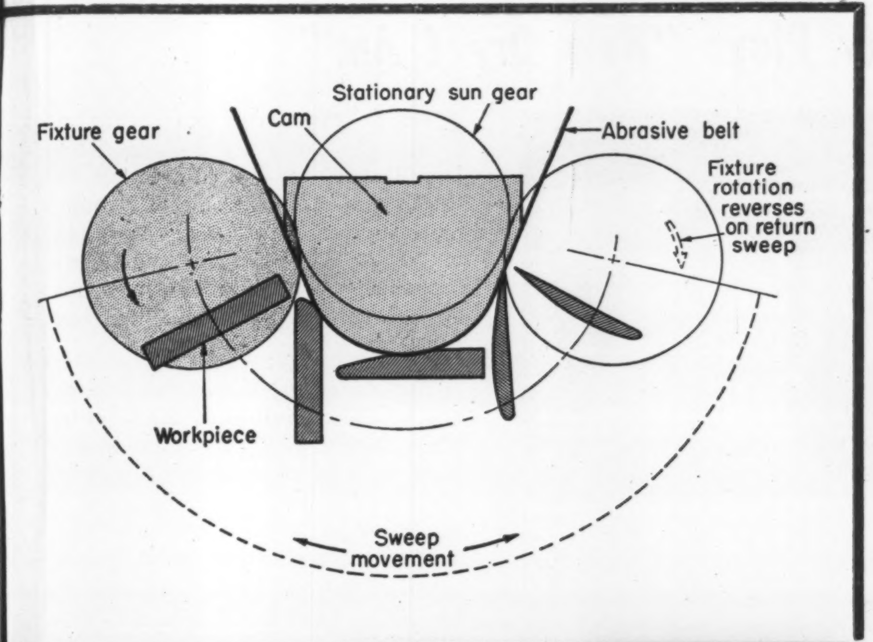
The bed slide is in the form of a closed box, held in the upper guides by flexible bronze bar "springs" that press the slide against the lower face of the bed even under no-load conditions, thus eliminating clearance between the guides and bed slide. Cutting forces are supported between the guides, unlike conventional designs in which main cutting forces are transmitted to the end of the slide. Uniform feed movement is obtained, since the centerline of the hydraulic feed piston operating the slide is only 2½ inches from the cutting edge of the tool. A swinging tool arm is hydraulically operated.

Turbine Blade Profiles Generated by New Method

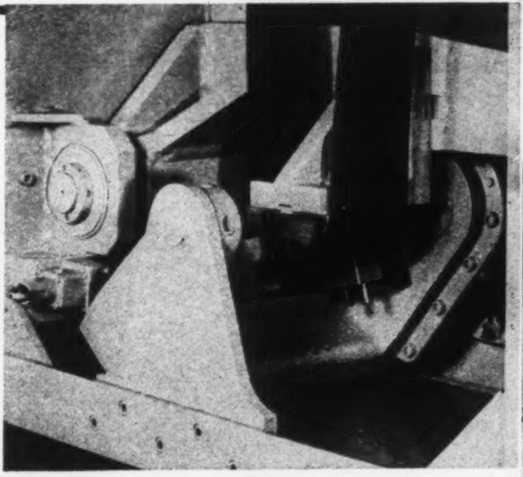
A UNIQUE method of generating turbine blade or bucket profiles is incorporated in the Generating Belt Grinder of Planet Products Corp. Additionally, hydraulic controls have been "panelized" to reduce number and length of hydraulic lines.

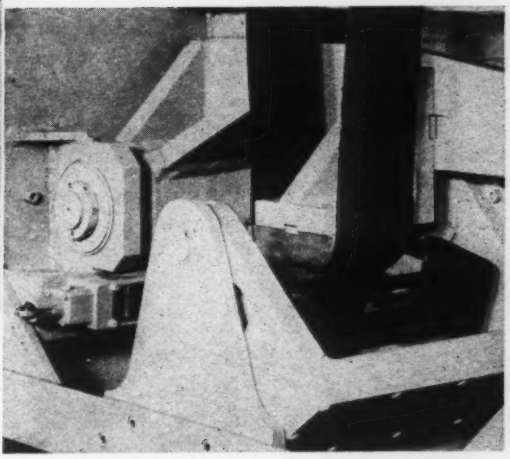


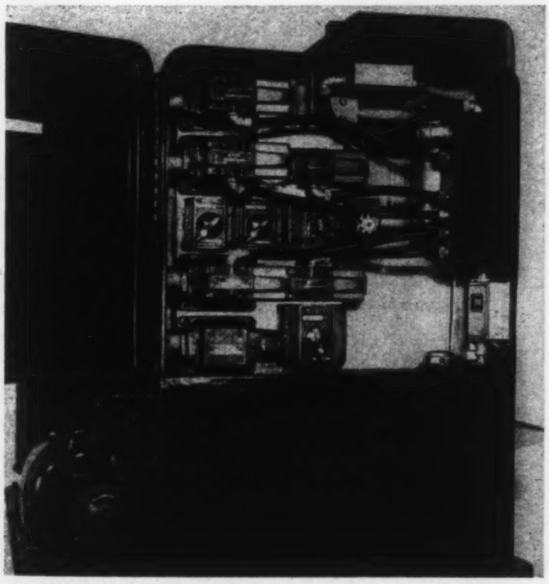
An abrasive belt, passing over a master cam, grinds the stock to the desired profile. The belt is direct-driven by a 15-horsepower motor with the abrasive side of the belt facing the motor pulley, permitting the back side to be lubricated. Mounted on a cantilever arm, the master cam is moved into position at the beginning of the cycle by a hydraulic piston. Cam feed rate and position are fully adjustable. The tensioning pulley is hydraulically loaded, and idler pulleys are independently adjustable for direction and angle of tilt, and axial position.



In operation, the workpiece is held in a fixture inside a cradle. Sweep movement of the cradle through a 160-degree arc is combined with rotation of the fixture to generate profiles ranging from convex to relatively flat. A hydraulically operated rack and gear swings the cradle, automatically rotating the fixture through a planetary gear system with a stationary sun gear. Shape of the cam is easily determined for each job by mounting a master blade in position and rotating it against a plastic-faced master cam. The resulting cam shape is then duplicated in steel, hardened, and chrome-plated. A similar machine has also been developed for grinding concave shapes, in which functions of the cam and workpiece are reversed.



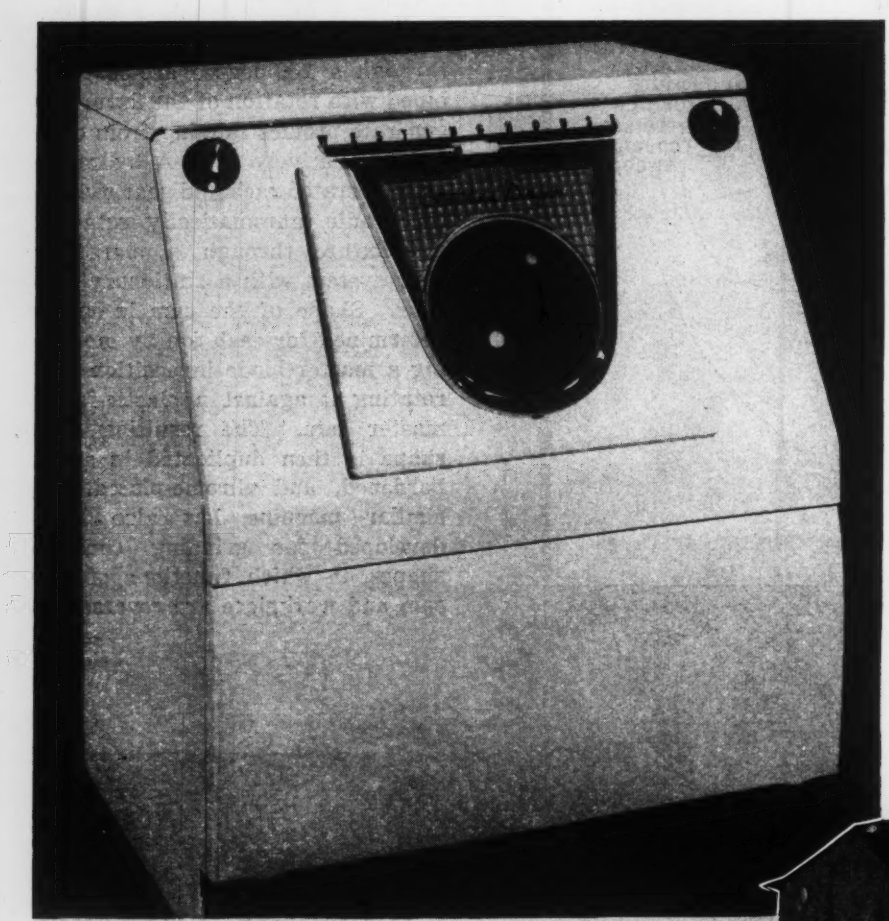




One feature which has been stressed in the design of the grinder is the unitization and grouping of all controls. A hydraulic panel on the left side of the machine, for example, contains all hydraulic valves except the pilot reversing valve near the sweep assembly, similar to the panelized electrical controls on the right side of the machine. Sandwich-plate construction of the hydraulic panel eliminates complex fluid-line layouts and unnecessarily long lines.

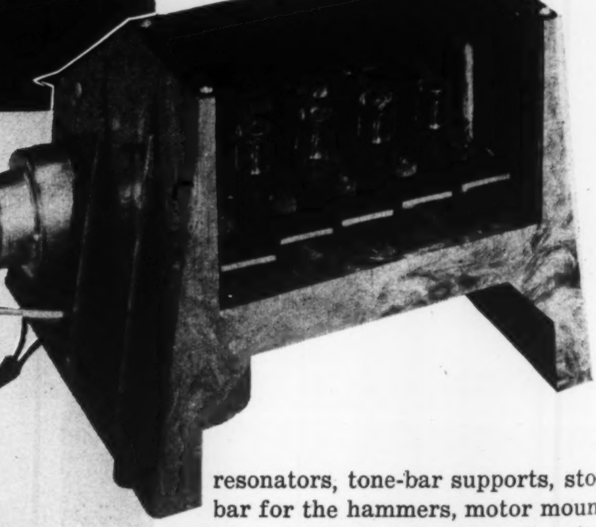
CONTEMPORARY DESIGN

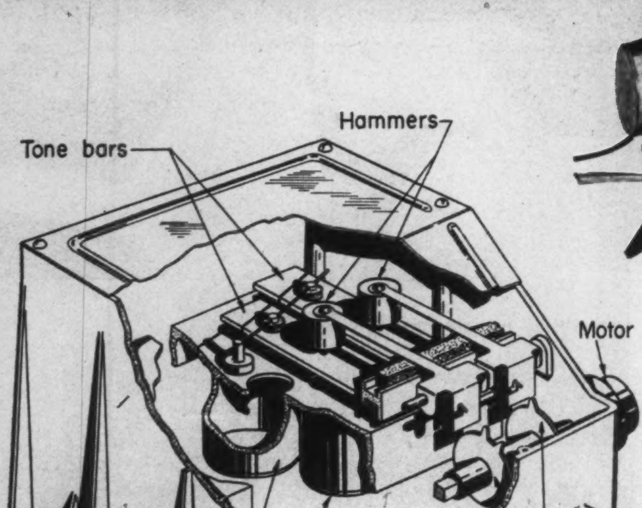
Clothes Dryer Plays "How Dry I Am"



FIRST announced last fall, a unique clothes dryer plays "How Dry I Am" at the completion of the drying cycle. A specially built motor-driven music box, designed by W. A. Wasemann of the Westinghouse Appliance Engineering Department, is responsible for the tune.

The sound-producing steel bars are made of full-hard SAE 1010 strip, instead of special alloy steels used in expensive musical instruments. The bar is supported at the nodes, or points of zero vibration; support at any other point would result in a weak tone or no tone at all. Steel of exceptionally uniform thickness is needed since variations in thickness produce much greater changes in pitch than similar variations in length. A one-piece plastic frame serves as the enclosure, resonators, tone-bar supports, stopbar for the hammers, motor mounting, camshaft bearing and switch mounting.

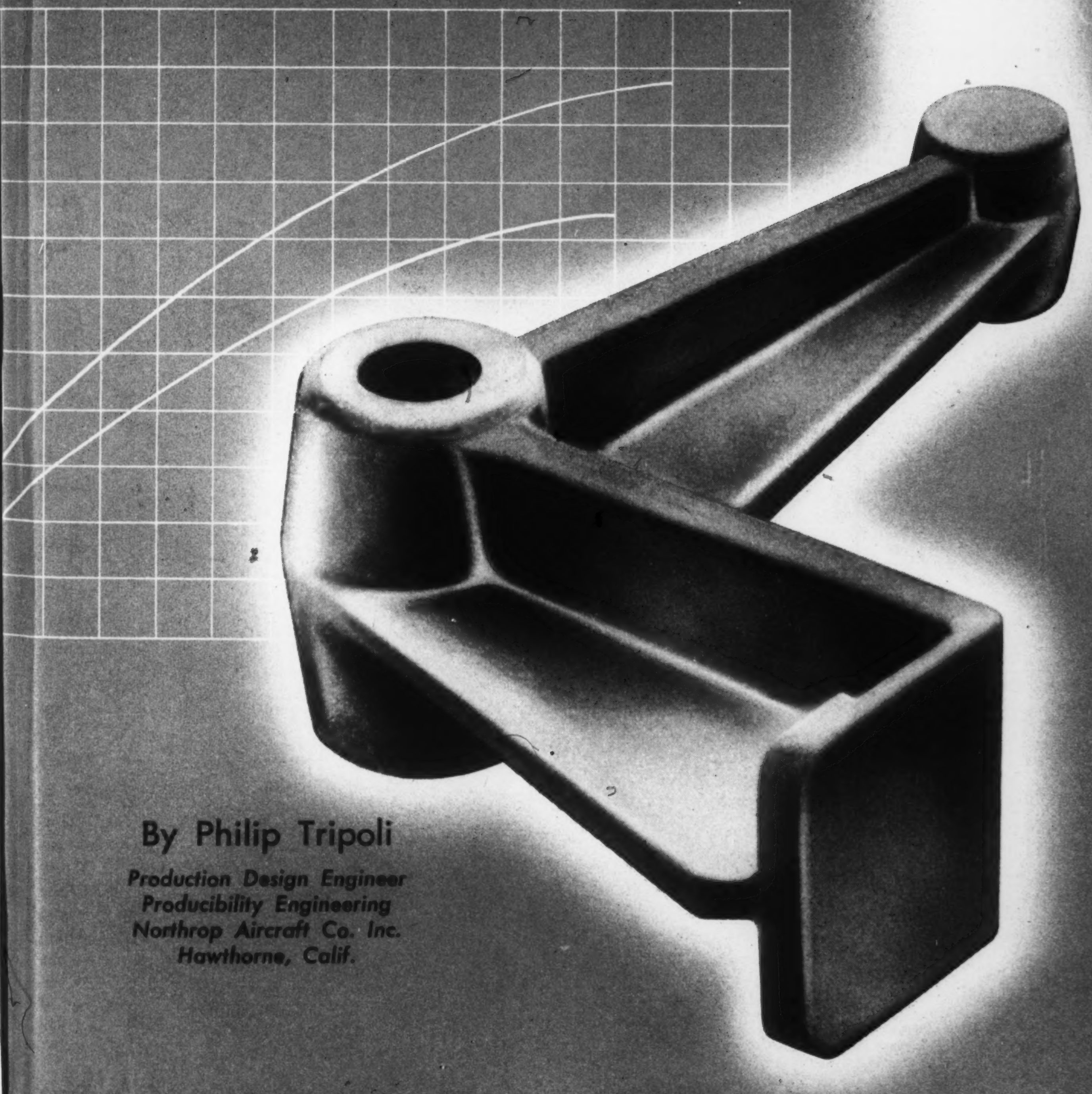




Hammers are actuated by "timing" cams driven by a small motor. Resonating chambers of the Helmholtz type, which reinforce the tones, operate like a spring and weight vibrating system in which the slug of air between the tone bar and resonator constitutes the vibrating mass, and the cushion of air inside the closed body, the spring.

PREDICTING CASTING COSTS

Based on statistical analysis of actual parts, this article presents a scientific approach to the accurate determination of casting costs at early design stages.



By Philip Tripoli

Production Design Engineer
Producibility Engineering
Northrop Aircraft Co. Inc.
Hawthorne, Calif.

PREDICTING
PRODUCTION

Fig. 1—Adequate casting data permit rapid evaluation of designs and maximum simplicity and economy in production

PREDICTING CASTING COSTS

. . . with accurate design yardsticks

PREDICTION of casting costs has always been a somewhat elusive and plaguing problem in design. The engineer can design a highly satisfactory casting, but will it be the most economical method of producing the desired design? The answer to this question is highly significant, for in a competitive market the criterion of a good design is the cost to produce it.

The emphasis on costs has engendered the need for a group of design consultants whose primary function is to evaluate the various methods of producing a desired design and to suggest that method which promises least difficulty and greatest economy in production. These consultants are known by various titles such as, cost engineers, production engineers, value analysts, or, as at Northrop, design producibility engineers.

Since the designer consults with the producibility engineer in the embryonic stages of design, it is apparent that the latter must have access to cost data which will permit a rapid and accurate evaluation of the items under consideration, *Fig.* 1. Such data is generally available for the common methods of production, but not for the evaluation of designs proposing the use of castings. Of course, estimates have been offered on such occasions, but the estimate has been based on a rule-of-thumb which has varied, and quite appreciably, with the estimator. Realizing the need, an attempt has been made at Northrop to develop data which would furnish a basis for determining (with reasonable accuracy) the cost of castings.

Elements of Founding

Investigation of Casting Costs: Preliminary investigations on the feasibility of such a study proved fruitful. The Materiel Division had a complete record of the casting purchases and such pertinent information as the casting material; the price paid for each casting; the type of pattern (e.g., metal pattern on metal plate, metal pattern cast on plate, loose wood pattern, etc.) and its cost; the cavities produced by the pattern at each molding; the weight of each raw casting as trimmed by the foundry; the quantity of cores, if any, required in the production of each casting (knowing the amount of cores required in the production of each casting expedited the early statistical work and assured accuracy of the final data); and the vendors from whom the castings were purchased.

Fortified with the knowledge that the basic data for statistical analysis was available, some of the leading foundries were consulted to determine which elements in founding contributed most to the cost of a casting, and by what proportion each factor affected the cost, *Fig.* 2. In analyzing the numerous elements, it was realized that it would be necessary for ease of application to group them into a minimum of categories. Therefore, the *elements of evaluation* were resolved into the following processes or operations (For ease of presentation these elements are defined later):

1. Molding.
2. Melt and pour.
3. Shake-out, cleanup, and trimming.
4. Coring.
5. Miscellaneous.

The next phase of the study consisted of the statistical analysis of the magnesium alloy sand casting data obtained from Purchasing. (Choice of magnesium castings was made because it offered a reasonable sample size for the analysis). The results of this analysis justified reaching four conclusions of primary importance:

1. The data, applicable to 95 per cent of the magnesium alloy sand castings designed at Northrop, limits the size of the casting to one which can be produced from a bench-type mold; i.e., the flask size permits the molding operation to be performed predominantly by one man (Flask sizes which can be handled by one man vary, but for general conditions a 14 by 18 inch flask is considered limiting).
2. Each element of evaluation had to be classified as to degree of difficulty. It was decided to have five classes; A,B,C,D, and E (where A is simple and ascends to E difficult). But this classification of difficulties is also limited to 95 per cent of the cases. The E classification is not the most difficult condition imaginable, but one which conforms to the pattern established by the present designs as being relatively difficult.
3. The increment of cost for successive degrees of difficulty was not uniform throughout the range; the increase was greater between C and D than between B and C.
4. With the exception of the coring process, even though the flask cost was affected by the number of cavities, the increase was not proportional.

Cost Breakdown

Development of Evaluation Data: The next step in the study was to predict casting costs from the formulated results of the analysis and compare these values against the actual costs. In the early stages of this testing it was apparent that certain factors influenced the degree of difficulty of each element of evaluation. These factors and a definition of the elements are discussed in the following paragraphs.

MOLDING: The molding process consists of the preparation of the mold up to the point where it is ready for the pour. There is one important exception to this definition: the placement of the core or cores in the mold has been included as a cost function of the coring process. Other factors in the molding process which influence cost are:

1. When the pattern is entirely on one side of the parting line, the element of difficulty for removing the pattern is reduced over a similar pattern which extends into the mold on both sides of the parting line.

2. The depth that a pattern extends into the sand on one side of the parting line normally increases the classification of difficulty. The breakdown was approximately as follows:

1. A-B — Up to 1.4 inches depth.
2. C — 1.5 to 2.4 inches depth.
3. D — 2.5 to 3.4 inches depth.
4. E — 3.5 to 5.0 inches depth.

3. Above this depth a "cheek" (an intermediate section of the flask, located between the cope and drag) is usually necessary to provide the necessary cushion of sand. The cheek increases the molding cost by 50 per cent.

4. The area of the section extending into the sand affects the classification when the pattern is being removed. A small cross section tends to disrupt the sand more than a larger cross section; the repair is more tedious.

5. When a casting hole is formed by green sand, the smaller the size of the hole (for a given depth) the more difficulty will be experienced in removing the pattern.

CASTING TERMS

CAVITIES:
A cavity is an integrated hollow in a mold which, when filled with molten metal, becomes a single casting. When the pattern is arranged to produce more than one cavity of the same design, the mold so created becomes a multicavity mold.

COPE:
See Flask

CORE:
As used here, a core is molded of sand (containing special binders) which is baked to form a model of a shape within the mold from which it is intended to withhold metal. When the casting is removed from the sand the core is knocked out, leaving the desired void within the casting.

DRAG:
See Flask

FLASK:
A frame, open top and bottom, in which the molding sand is prepared to receive the casting metal. This frame may be of several sections but normally it consists of a top half called the cope, and bottom half called the *drag*.

GATING:
A system of passages in the sand for feeding molten metal to the cavities.

PARTING LINE:
The parting line is generally the plane where the *cope* and *drag* sections of the flask separate.

PATTERN:
A pattern is a model for producing the mold in the sand. Most precision patterns are of metal mounted on a metal plate.

RISER:
A riser is a reservoir from which molten metal is drawn to compensate for shrinking of the cooling metal within the mold.

SPRUE:
The sprue is the opening which receives the molten metal and passes it to the gating for delivery to the mold.

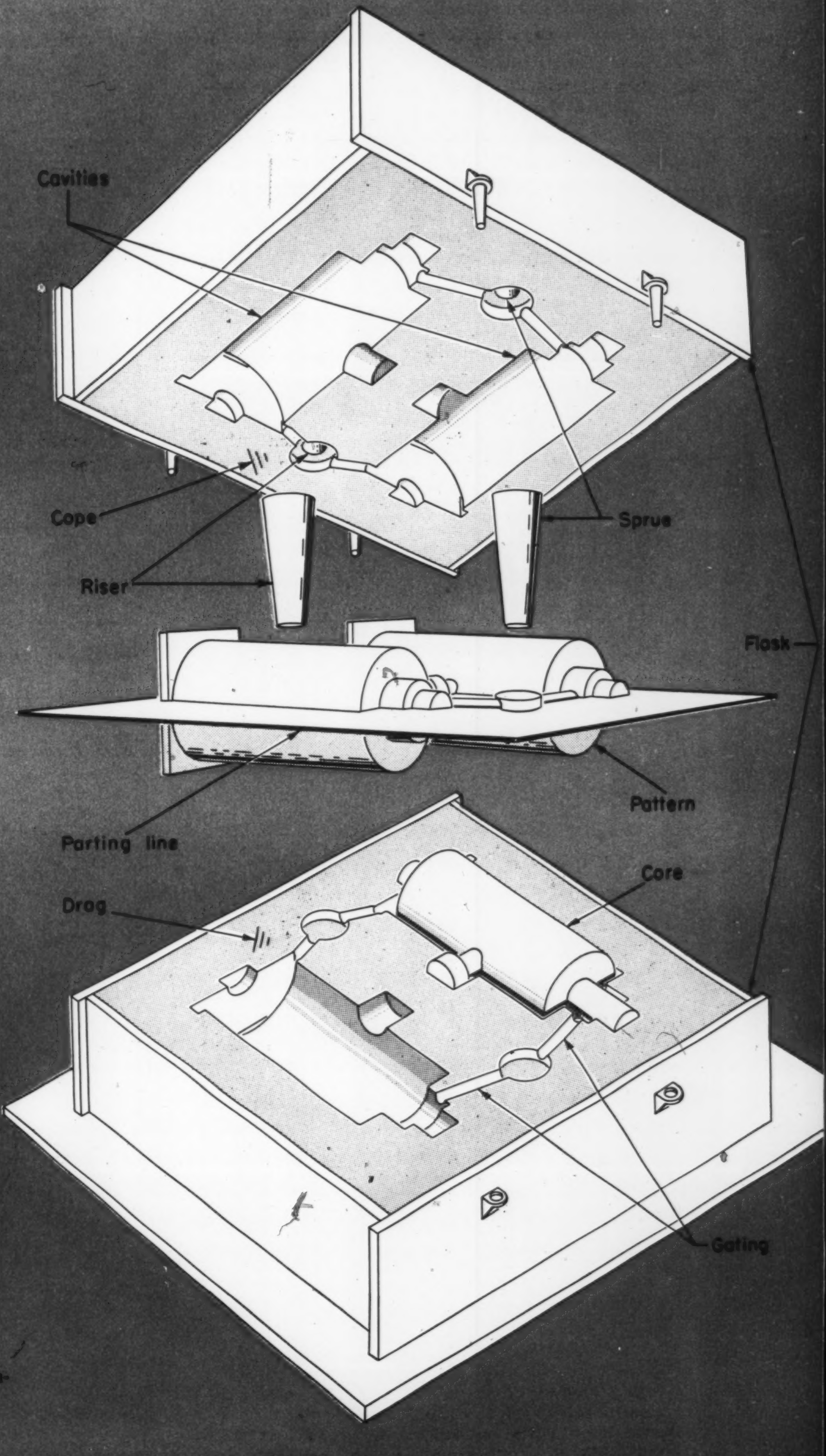


Fig. 2—Basic elements and terminology applying to sand casting

6. When removing the pattern, the smaller the radii of surfaces normal to the parting line the more difficulty will be experienced in making a clean break.

7. There are instances when the effect of coring produces a pattern configuration which forms a simply defined mold in contrast to an irregular shaped part. Therefore, the molding process must be visualized in terms of the influence of the core on the pattern.

Melt and Pour: It is realized that the melt and pour costs are a function of the amount of metal poured as well as the problems inherent in feeding the metal to all areas of the casting. Since there is no simple way of determining the amount of metal poured, cost has been empirically arrived at as \$.60 per pound of magnesium alloy melt required to produce the raw casting (as trimmed by the foundry). *To this is added a classification cost.* The classification is then influenced by the following criteria:

1. Section thicknesses in relation to each other affect the cooling process which may create strains in the casting that result in cracks.

2. Large surface areas require more gating which requires more metal to be poured.

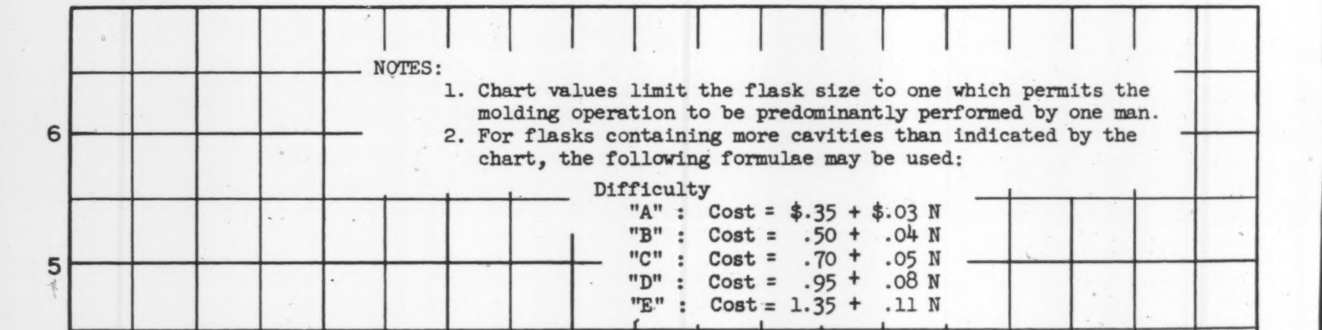
3. Thick sections require risers to feed the section as the metal cools, again requiring more metal to be poured.

4. Thin sections have a tendency to cool rapidly, thereby presenting a feeding problem when the metal has to travel far.

Shakeout, Cleanup, and Trimming: This includes shaking the sand from the flask, knocking out the coring, cleaning the sand from the casting (or castings), removing gating and risers and trimming flash from the castings. Of these the trimming contributes most to the cost; a secondary factor is the amount of gating and risers which have to be removed. The factors which influence the cost are:

1. Extent of the surfaces where flash occurs. (Note: Flash occurs at ~~the~~ parting line and where the cores and green sand come together).

Fig. 3—Chart giving flask cost of the molding process



NOTES:

1. Chart values limit the flask size to one which permits the molding operation to be predominantly performed by one man.
2. For flasks containing more cavities than indicated by the chart, the following formulae may be used:

Difficulty
"A" : Cost = \$.35 + \$.03 N
"B" : Cost = .50 + .04 N
"C" : Cost = .70 + .05 N
"D" : Cost = .95 + .08 N
"E" : Cost = 1.35 + .11 N

2. Difficulty of and the accessibility for removing the flash; e.g., a straight surface may be ground off on a disk grinder while a multicurved surface would require a rotary file.

3. Clealiness and tolerances of finish desired by the design.

4. Difficulty of shaking out the coring from the finished casting.

CORING: The coring costs are a function of making the core as well as its placement in the mold. Some of the factors which influence the cost are:

1. Tolerances of the core or cores.

2. Thinness of sections which may introduce warpage.

3. Difficulty of ramming the core box to produce a firm core.

4. Difficulty of parting the core box to produce a satisfactory core.

5. Matching or alignment of cores to form web thickness.

6. Placement of the core in the mold. If the core is placed in the drag half of the flask and does not extend above the parting line, the classification is less difficult than one which extends on both sides of the parting line. If the core is placed in the drag half of the flask, the depth that the core extends into the cope half of the flask increases the difficulty. If the core is placed in the cope half of the flask, it creates a greater problem than if that same core were placed in the drag half of the flask.

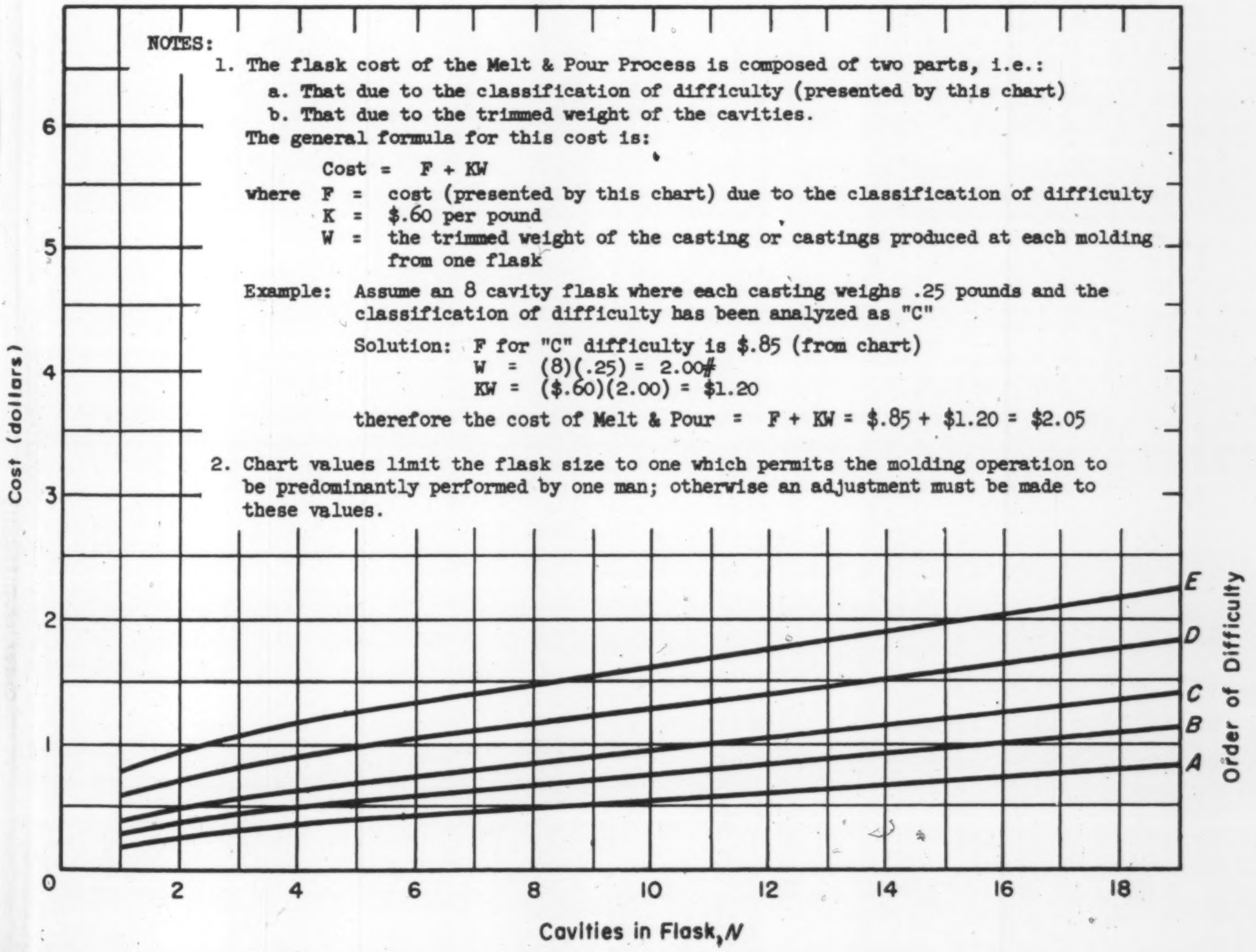
MISCELLANEOUS: The miscellaneous costs are those costs not covered by the other elements discussed above. The miscellaneous costs are affected by the following:

1. Tolerances and surface finish to be maintained in production.

2. Casting classification (i.e., the stress requirements) and X-ray requirements.

3. Amount of straightening necessary because of

Fig. 4—Flask cost plot for the melt and pour process



NOTES:

1. The flask cost of the Melt & Pour Process is composed of two parts, i.e.:
   a. That due to the classification of difficulty (presented by this chart)
   b. That due to the trimmed weight of the cavities.

The general formula for this cost is:

Cost = F + KW

where F = cost (presented by this chart) due to the classification of difficulty
K = $.60 per pound
W = the trimmed weight of the casting or castings produced at each molding from one flask

Example: Assume an 8 cavity flask where each casting weighs .25 pounds and the classification of difficulty has been analyzed as "C"

Solution: F for "C" difficulty is $.85 (from chart)
W = (8)(.25) = 2.00#
KW = ($.60)(2.00) = $1.20

therefore the cost of Melt & Pour = F + KW = $.85 + $1.20 = $2.05

2. Chart values limit the flask size to one which permits the molding operation to be predominantly performed by one man; otherwise an adjustment must be made to these values.

the part configuration.

4. Possible rejection rate because of the section thicknesses which might create cracks or porous conditions.

5. Classification assigned to the other elements (this has a strong influence on the miscellaneous classification; generally it will be at least the average of those classifications.)

Charting of Costs

Results of Evaluation: When final refinements had been made to the evaluation data, five charts, shown in *Figs.* 3 to 7 inclusive, were prepared to provide the basis for determining the costs of magnesium alloy sand castings. Each chart has five curves representing the cost for five degrees of difficulty. It must be realized that the charts permit a finer classification than the curves provide by interpolating in the area between the curves.

Using the information on the charts to predict the cost of 170 various castings, the author made the following scores:

Plus or minus error as a percentage of actual cost	Frequency of such error
0.0- 4.9	30
5.0- 9.9	38
10.0-14.9	26
15.0-19.9	27
20.0-24.9	18
25.0-29.9	11
30.0-34.9	9
35.0-39.9	3
40.0-44.9	0
45.0-49.9	2
50.0-54.9	3
55.0-59.9	1
60.0-64.9	1
65.0-69.9	1
	170

The average error is plus or minus 15.9 per cent.

The probability of predicting within plus or minus 20.0 per cent error is 0.71. However, such exigencies as tight delivery schedules, prototype requirements, etc., sometimes make it necessary for the purchasing department to pay premium prices for an item; in addition, it is not an uncommon practice for vendors to underbid or overbid on an item depending on their shop loading. Realizing this, it was decided to investigate the costs of some of those castings in which the error of prediction was greater than plus or minus 20 per cent. Therefore, eight castings were selected in which five showed a plus error greater than 20 per cent, and 3 showed a minus error of greater than 20 per cent. Rebids on these castings were requested of three vendors. These quotations fluctuated as indicated below:

Bid Quotation Per Piece ($)

Part	X	Y	Z
A	1.65	1.25	0.98
B	0.41	0.60	0.61
C	1.85	1.72	1.10
D	0.52	0.66	0.58
E	1.35	1.20	0.82
F	4.90	3.90	2.41
G	0.42	0.47	0.24
H	1.85	3.69	2.30

It was decided to use the *median* quotation in each instance (e.g., for A, $1.25 was chosen; for H, $2.30 was chosen). These results showed the following change in the error:

Part No.	Error Based on Original Cost	Error Based on Chosen Quotation
A	−22.5%	− 5.8%
B	−30.5	−10.8
C	+42.5	− 7.2
D	−42.5	−22.8
E	+29.8	+ 2.7
F	+52.5	+ 1.3
G	+52.5	−27.4
H	+30.6	+ 7.8

The purpose of this analysis is to demonstrate that reliable predictions can be made on the *average* price which can be expected to be paid for a casting. For the sample above, the arithmetic average error of predicting was reduced from plus or minus 37.9 per cent to plus or minus 10.7 per cent, which indicates that the author's scores could be measurably improved on the basis of a *median quotation.* (Note: the author's scores are all based on the original costs.)

Another interesting point is that the plus errors and minus errors practically cancelled each other, which is a strong indication that the evaluation data presented here are highly credible.

In order to test the method of evaluation on other personnel, a random sample of the magnesium sand casting drawings was presented to three other producibility design engineers. They were requested to indicate *their own* estimate of the cost and then to evaluate the cost by the method expounded in this article. No instructions other than the text so far presented were provided them.

The score of one engineer was as follows: By his own system he was able to estimate within plus or minus 20 per cent error 16 out of 41 times in contrast to 27 out of 41 times by this report method. Nine out of 41 of his estimates were further out than the worst of the report method evaluations. The plus and minus error came to minus 17.7 per cent for his estimate in contrast to minus 0.23 per cent for the report method.

Another producibility design engineer estimated within plus or minus 20 per cent of actual costs 15 out of 41 times by his own method in contrast to 26 out of 41 times by the report method.

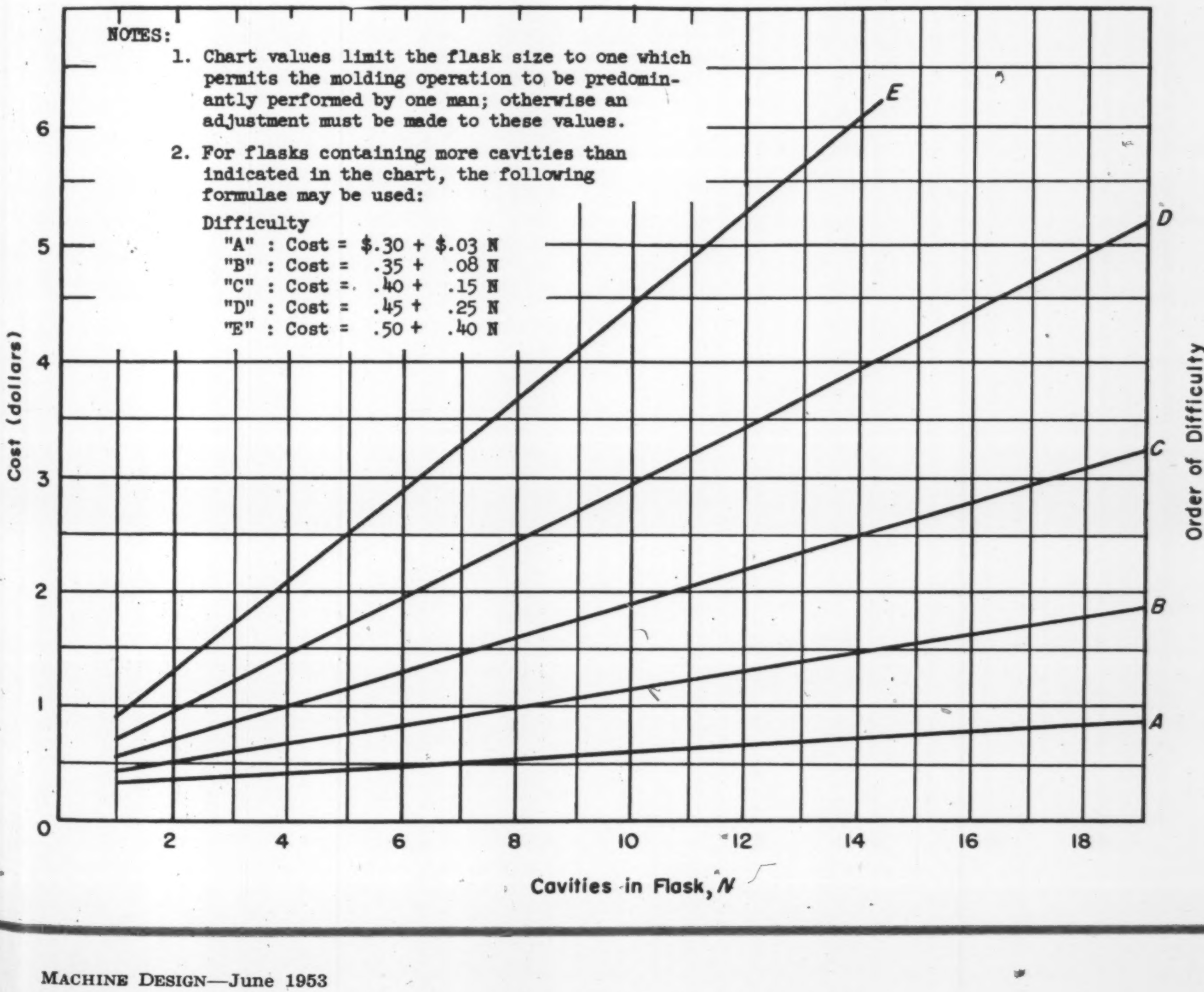
Then a composite classification of the random samples was considered. The selection was made as follows: If three (of the four) or more evaluators classed the difficulty for a given element in the same category, that classification was considered the most probably correct. Otherwise the average of the classification was accepted as being most correct. For this composite, the goodness of predicting within plus or minus 20 per cent of actual costs was 29 out of 41 cases, (0.708). This (0.708) probability is very close to the 121/170 = 0.713 probability of predicting within plus or minus 20 per cent error established by the author.

Design Yardsticks

Establishing the Degree of Design Complexity: At this stage in the development it was decided to establish a "yardstick" for determining the degree of difficulty of each element of evaluation. Therefore, the drawings of the random sample were carefully analyzed by the author and the casting and forging engineer, and were placed in an ascending order of difficulty for the molding process. Retaining this order, the sample was divided statistically into ten groups; i.e., A, A+, B, . . E, E+ classification of difficulty. This procedure was followed for each of the other elements of evaluation.

Then the random sample was re-evaluated on the

Fig. 5—Chart showing flask cost of shakeout, cleanup and trimming process



NOTES:

1. Chart values limit the flask size to one which permits the molding operation to be predominantly performed by one man; otherwise an adjustment must be made to these values.
2. For flasks containing more cavities than indicated in the chart, the following formulae may be used:

Difficulty
"A" : Cost = \$.30 + \$.03 N
"B" : Cost = .35 + .08 N
"C" : Cost = .40 + .15 N
"D" : Cost = .45 + .25 N
"E" : Cost = .50 + .40 N

basis of the classifications obtained from the process outlined in the above paragraph, and the following scores obtained:

Plus or minus error as a percentage of actual cost	Frequency of such error
0.0- 4.9	12
5.0- 9.9	10
10.0-14.9	4
15.0-19.9	8
20.0-24.9	3
25.0-29.9	2
30.0-34.9	1
....	..
45.0-49.9	1
	41

The average error was plus or minus 12.2 per cent.

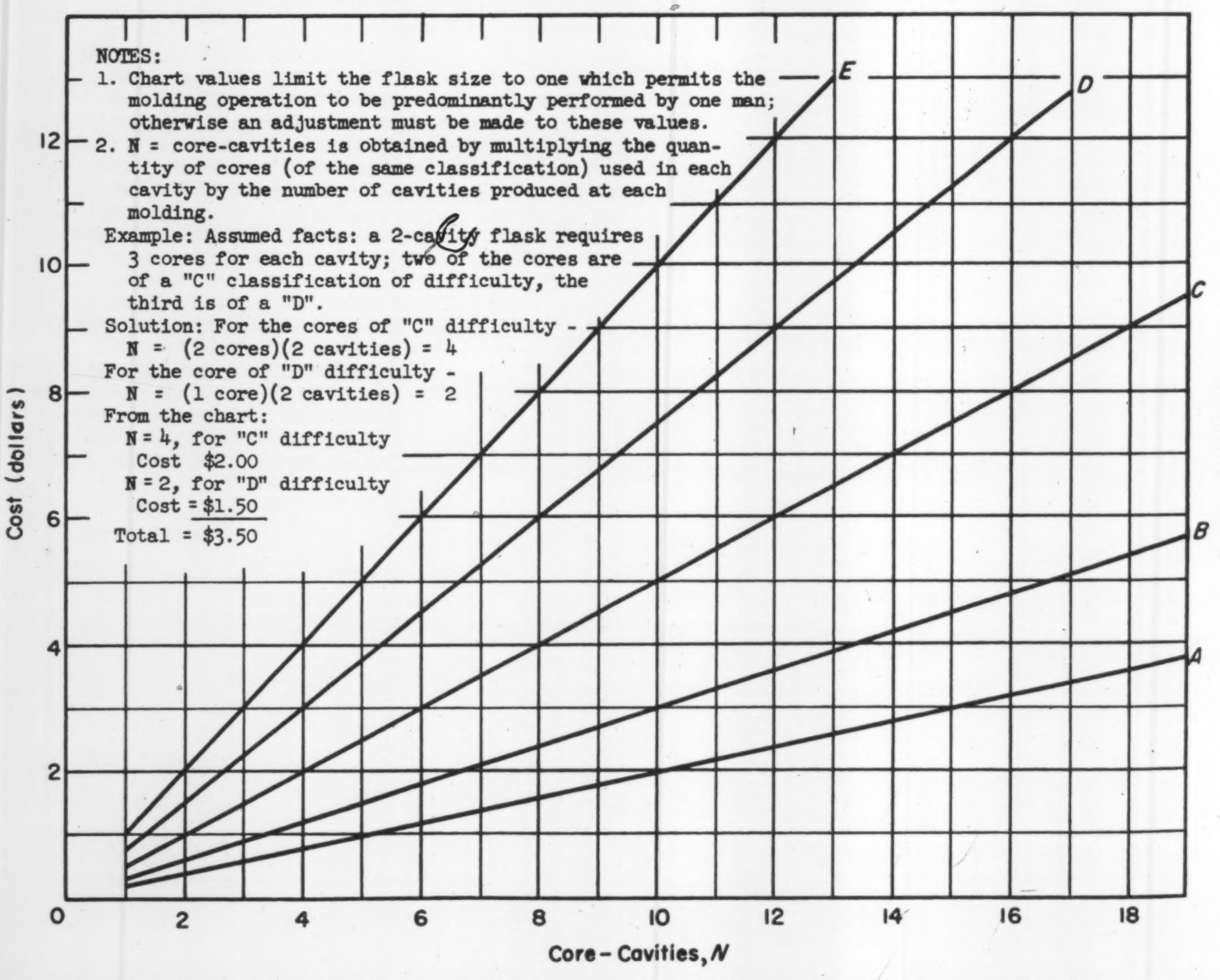
The probability of predicting within plus or minus 20.0 per cent error is 34/41 = 0.83. The results previously detailed, obtained as a consequence of new bid quotations on those castings in which the error of predicting exceeded plus or minus 20 per cent would lead us to believe that a higher probability than 0.83 could be obtained if this correction were effected.

The better scores obtained in the reappraisal of the random sample (resulting from the classification of difficulty in an ascending order) were convincing proof that production illustrations, *Fig.* 8, were necessary to afford a method of gaging the difficulty of the elements of evaluation for any given design.

Cost Evaluation

Analyzing a Design: In addition to these illustrations, the listing in Table 1 shows the complete classi-

Fig. 6—Plot of values for flask cost of the coring process


NOTES:

1. Chart values limit the flask size to one which permits the molding operation to be predominantly performed by one man; otherwise an adjustment must be made to these values.
2. N = core-cavities is obtained by multiplying the quantity of cores (of the same classification) used in each cavity by the number of cavities produced at each molding.

Example: Assumed facts: a 2-cavity flask requires 3 cores for each cavity; two of the cores are of a "C" classification of difficulty, the third is of a "D".

Solution: For the cores of "C" difficulty -
N = (2 cores)(2 cavities) = 4
For the core of "D" difficulty -
N = (1 core)(2 cavities) = 2
From the chart:
N = 4, for "C" difficulty
Cost $2.00
N = 2, for "D" difficulty
Cost = $1.50
Total = $3.50

fication for each part. When analyzing any given design the illustrations and the listing furnish ample examples for judging the degree of difficulty of the elements of evaluation. The illustrations are identified by a numeral and a letter; the numeral indicates the element of evaluation—1 for molding, 2 for melt and pour, etc.—and the letter indicates the classification of difficulty for the specified element.

Application: The use of the illustrations, listing, and charts can best be demonstrated by the following problem and its solution.

Problem: To find the cost of Sample Part "XX" casting, *Fig.* 9, as delivered from the vendor's foundry.

Solution: Sample part XX is compared with the production illustrations, *Fig.* 8, to determine the classification of difficulty for each element of evaluation.

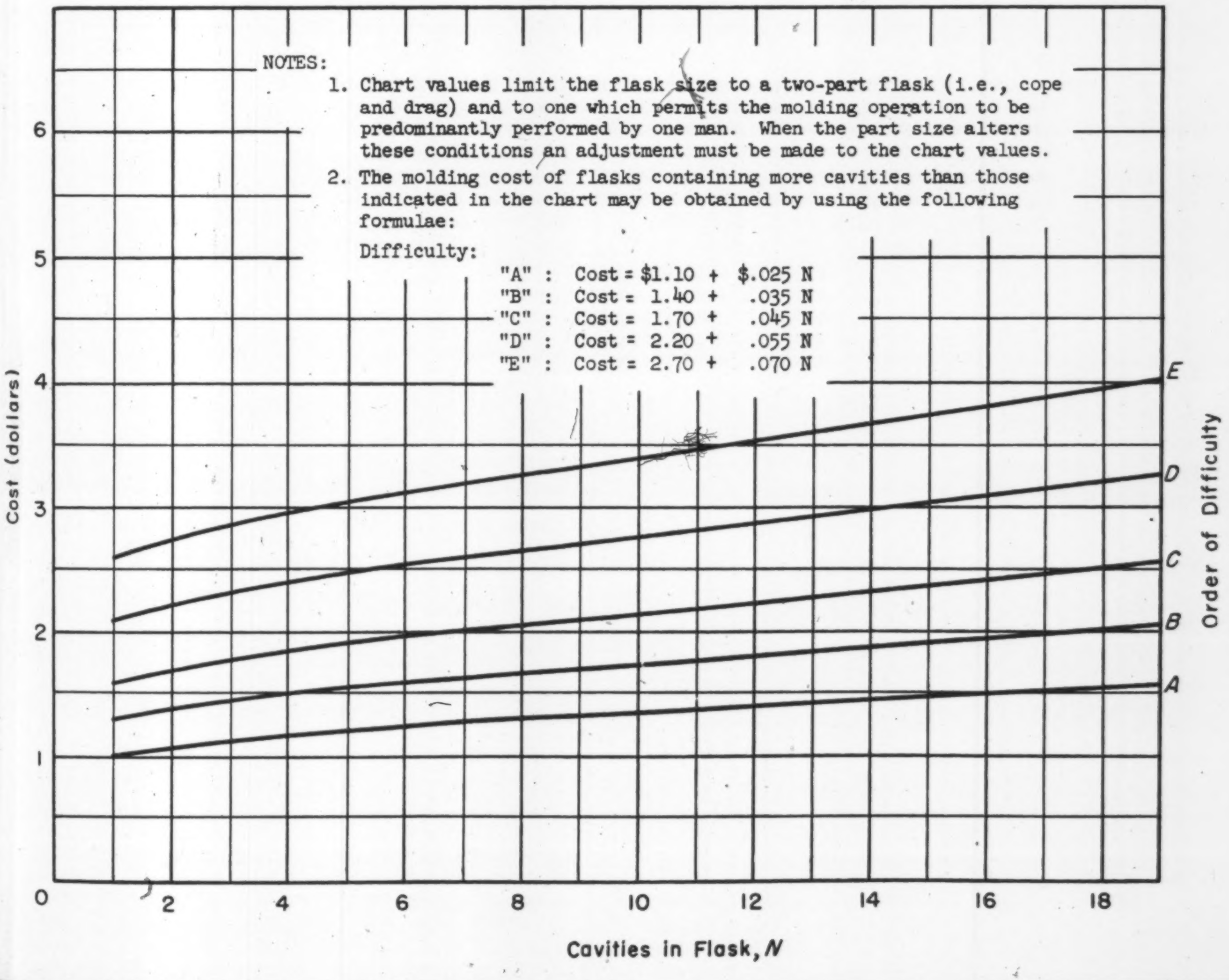
Molding: The maximum depth of the part from the parting line is approximately 1½ inches. Examination of the illustrations shows certain similarity, with respect to molding, to 1B. It is not quite as difficult as 2C (whose molding classification, from Table 1, is C). It appears slightly more difficult than 3B (whose molding classification is B). Therefore, it might be logical to use a value of B+.

Melt and Pour: With respect to melt and pour, there is a similarity to 2B, and so a classification of B is chosen.

Shakeout, Cleanup & Trimming: With respect to the shakeout, cleanup and trimming there is a similarity to 2B (whose shakeout, cleanup and trimming classification, from Table 1, is C). The extra holes and end opening, and the irregularity of sample part XX may be considered to be offset by the additional surfaces to be trimmed from 2B because of the position of the latter's parting line. Therefore, a classification of C is chosen.

Coring: With respect to the coring process, again there is a similarity to 2B (whose coring classification is B+). Therefore, B+ is chosen as the classification.

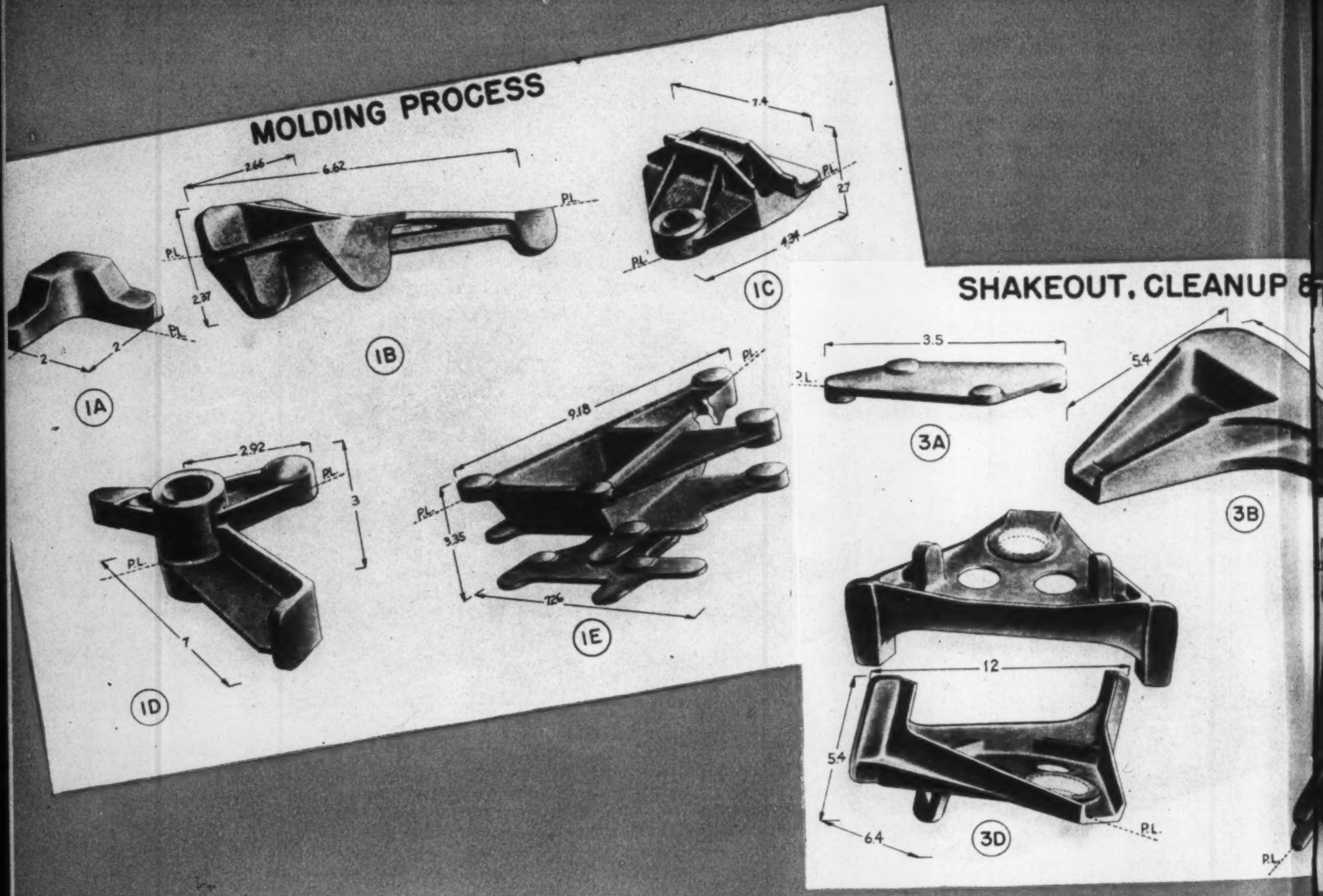
Fig. 7—Chart giving flask costs of miscellaneous operations and factors

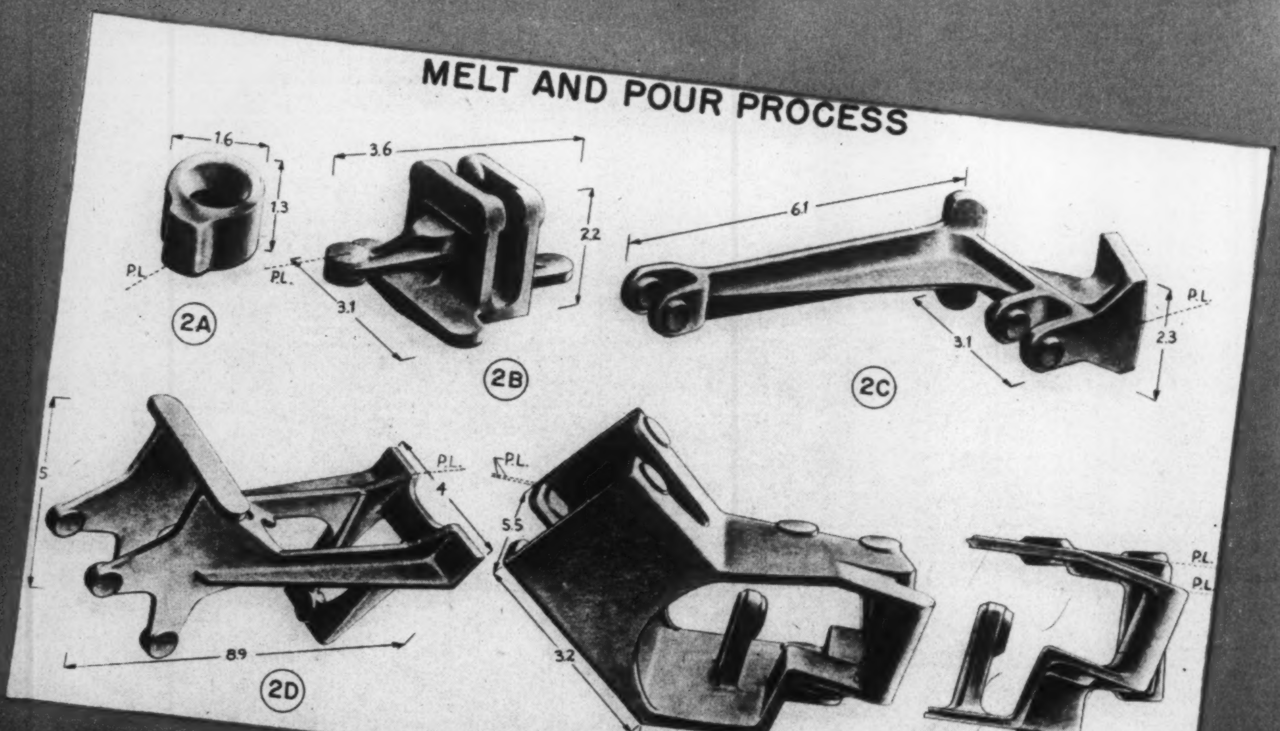

NOTES:

1. Chart values limit the flask size to a two-part flask (i.e., cope and drag) and to one which permits the molding operation to be predominantly performed by one man. When the part size alters these conditions an adjustment must be made to the chart values.
2. The molding cost of flasks containing more cavities than those indicated in the chart may be obtained by using the following formulae:

Difficulty:

"A" : Cost = $1.10 + $.025 N
"B" : Cost = 1.40 + .035 N
"C" : Cost = 1.70 + .045 N
"D" : Cost = 2.20 + .055 N
"E" : Cost = 2.70 + .070 N


MOLDING PROCESS
2
2
P.L.
1A
2.66
6.62
P.L.
P.L.
2.37
1B
7.4
P.L.
2.7
P.L.
4.34
1C
2.92
P.L.
3
P.L.
7
1D
9.18
P.L.
P.L.
9.35
7.26
1E
SHAKEOUT, CLEANUP &
3.5
P.L.
3A
5.4
3B
12
5.4
6.4
3D
P.L.
P.L.


MELT AND POUR PROCESS
1.6
1.3
P.L.
2A
3.6
2.2
P.L.
3.1
2B
6.1
3.1
P.L.
2.3
2C
5
P.L.
4
8.9
2D
P.L.
5.5
3.2
3.5
P.L.
P.L.
2E

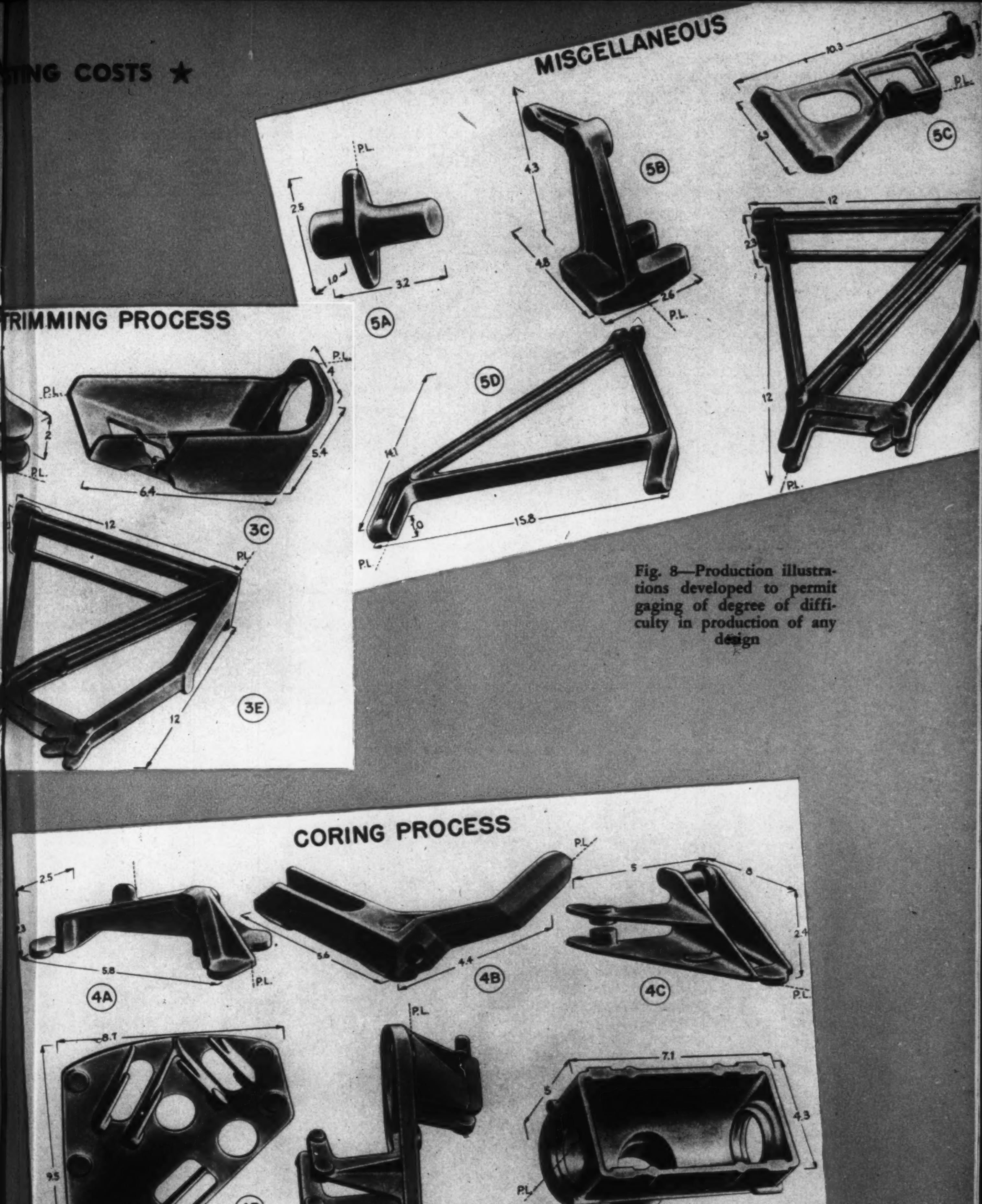

MISCELLANEOUS
P.L.
2.5
1.0
3.2
5A
4.3
4.8
2.6
P.L.
5B
10.3
P.L.
6.5
5C
12
2.3
12
P.L.
14.1
5D
15.8
1.0
P.L.
TRIMMING PROCESS
P.L.
P.L.
4
2
P.L.
5.4
6.4
3C
12
P.L.
12
3E
CORING PROCESS
2.5
2.3
5.8
P.L.
4A
P.L.
5.6
4.4
4B
5
8
2.4
P.L.
4C
8.7
9.5
4D
P.L.
7.2
7.1
5
4.3
P.L.
4E

Fig. 8—Production illustrations developed to permit gaging of degree of difficulty in production of any design

Miscellaneous: With respect to the miscellaneous consideration, again there is a similarity to 2B (whose Miscellaneous classification is B+). Therefore, B+ is chosen as the classification for sample part XX.

Calculations of Cost: The actual pattern produces a six cavity mold. (Determination of the amount of cavities to be expected is discussed later.) The weight of each casting is estimated as 0.18 pounds, the weight of 6 castings (comprising the flask) being 1.08 pounds.

Charts: The charts (*Figs.* 3 to 7 inclusive) are used for obtaining the costs of elements of evaluation for the chosen classification of difficulties. (Note: A plus sign after the letter classification indicates a region halfway between that letter and the letter representing the next higher degre of difficulty).

Fig. 3—Molding: A six-cavity flask with a B+ classification costs	$1.77
Fig. 4—Melt and Pour: A six-cavity flask with a B classification costs	.61
To which is added the weight cost of (1.08#) ($.60)	.65
Fig. 5—Shakeout, cleanup & Trimming: A six-cavity flask with a C classification costs	1.30
Fig. 6—Coring: Six core cavities with a B+ classification cost	2.40

Table 1—Classification of Difficulties For Parts

Part No.	Molding (*Fig.* 3)	Melt & Pour (*Fig.* 4)	Shake-out & Clean up (*Fig.* 5)	Coring (*Fig.* 6)	Miscellaneous (*Fig.* 7)
1 A	A	A	A	..	A
1 B	B	B+	B+	..	B
1 C	C	C+	C+	..	C+
1 D	D	C+	C	..	C
1 E	E	D+	E	C+	E
2 A	A+	A	A+	..	A+
2 B	C+	B	C	B+	B+
2 C	C	C	C+	..	C
2 D	D	D	E	E	D
2 E	C	E	D+	E+	D+
3 A	A	A+	A	..	A
3 B	B	C	B	B	C
3 C	C	B+	C	..	C
3 D	D+	E	D	..	D+
3 E*	D+	E	E	B(1),C+ (1), E(1)	E
4 A	C	B+	B	A	B
4 B	B	C	B	B	C
4 C	C+	D	D+	C	D+
4 D	E	D+	E+	D	E
4 E	C	D+	D+	A(2),E(1)	E
5 A	A	A+	A	..	A
5 B	C+	B	A+	..	B
5 C	B+	C+	D	..	C
5 D	B+	E	D	..	D
5 E	D+	E	E	B(1),C+ (1), E(1)	E

*Also listed as 5 E.

Fig. 9—Typical casting design used as an example for evaluation of basic costs

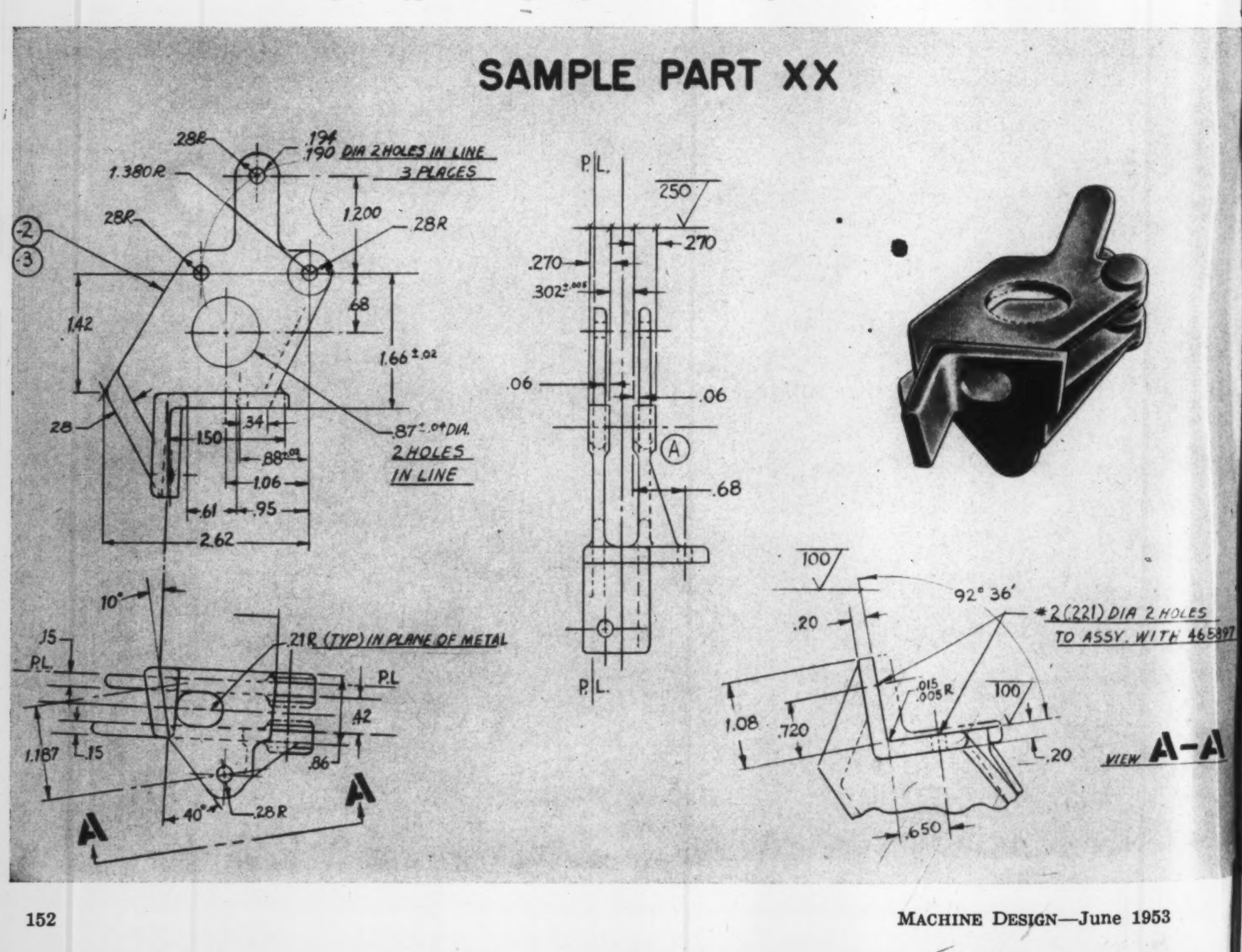

SAMPLE PART XX
.28R
.194
.190 DIA 2 HOLES IN LINE 3 PLACES
1.380R
1.200
.28R
.28R
-2
-3
1.42
.68
1.66 ±.02
.28
.34
1.50
.88±.02
.87±.04 DIA. 2 HOLES IN LINE
1.06
.61
.95
2.62
10°
.15
P.L.
.21R (TYP) IN PLANE OF METAL
P.L
.42
1.187
.15
.86
40°
.28R
A
A
P.L.
250
.270
.270
.302±.005
.06
.06
A
.68
P.L.
100
.20
92° 36'
*2 (.221) DIA 2 HOLES TO ASSY. WITH 465897
.015
.005 R
100
1.08
.720
.20
.650
VIEW A-A

Fig. 7—Miscellaneous: A six-cavity flask with a B+ classification cost .... .85

Total Flask Cost $7.58

Then $7.58/6 = $1.26 per casting. The actual price on this casting (on a six-cavity basis) is $1.16 per casting which gives an error of (0.10/1.16) 100 or + 8.62 per cent.

Cavity Consideration: So far, in the study, the amount of cavities which the pattern will produce has been taken as the known actual (obtained from the available records). This was done so as to eliminate *this* variable as a possible source of error. However, in any new design the amount of cavities which can be expected is an important part of the analysis.

Any cavity determination must consider two primary factors: i.e., the available area within the flask, and the economics of the situation. In this study it has been accepted that a flask size of 14 by 18 inches is generally used when multicavity molds are to be made. Therefore, with regard to space, the problem consists of taking the configuration of the pattern at the parting-line plane and determining how many of these shapes can be placed in the flask, making due allowances for an average 2 inch wall of sand around the perimeter of the flask, and for the area which will be occupied by the sprue, gating, and possible risers. *Fig.* 10 has been prepared to permit determination of the amount of cavities to be expected from the parting-line envelope of the pattern. The table is for *average* conditions which *may* be influenced by the following factors:

1. When coring is necessary, its anchoring may require extension of the parting line envelope size of the part.
2. The configuration of the part may permit more cavities than is evident from the parting-line envelope.
3. More cavities may be expected when the casting is simple (presenting no difficulty in gating, risering, and flowing of metal).
4. The rows of cavities are normally limited to two.
5. The number of cavities (above one) are normally even numbered unless the economics of the situation prevail.

Fig. 10 — Chart to permit determination of the number of cavities based on the parting line envelope of the pattern

L.D.* →	1.0	1.5	2.0	2.5	3.0	3.5	4.0	4.5	5.0	5.5	6.0	6.5	7.0	7.5	8.0	8.5	9.0	9.5	10.0 and over
S.D.** — 1.0	18	18	16	16	12	12	12	10	10	8	6	4	2	2	2	2	2	2	2
1.5		14	14	12	12	10	10	8	6	8	6	4	2	2	2	2	2	2	2
2.0			10	10	10	10	8	8	6	6	4	4	2	2	2	2	2	2	2
2.5				8	8	8	8	8	6	6	4	4	2	2	2	2	2	2	2
3.0					6	6	6	6	6	4	4	4	2	2	2	2	2	2	2
3.5						6	6	4	4	4	4	2	2	2	2	2	2	2	2
4.0							4	4	4	4	2	2	2	2	2	2	2	2	2
4.5								4	4	2	2	2	2	2	2	2	2	2	2
5.0									2	2	2	2	2	2	2	2	2	2	1
5.5										2	2	2	2	2	2	2	2	2	1
6.0											2	2	2	2	2	2	2	2	1
6.5												2	2	2	2	1	1	1	1
7.0													1	1	1	1	1	1	1
7.5														1	1	1	1	1	1
8.0															1	1	1	1	1
8.5																1	1	1	1

NOTES:

Based on 14" X 18" flask.

The envelope size is that of the pattern to produce one part.

For the area in the table within the double lines, if the casting configuration allows the metal to flow easily, more cavities than indicated can be expected.

KEY:

Assume that the envelope at the parting line plane is 4.33" X 2.98" (allowing for tolerances). Then the block common to the 4.5" (top of table) and the 3.0" (side of table) dimensions gives the figure 6 as the amount of cavities to be expected at each molding.

* Larger Dimension
** Smaller Dimension

6. Deep-draw parts will probably require more green sand spacing than average, thereby tending to reduce the cavity consideration.
7. When cast-in plates are required (due to irregular parting lines) and for table values of *less than* 6 *cavities*, there is a tendency to "squeeze" in as many cavities as the available area allows.
8. For the area in the table (Fig. 10) within the double lines, if the casting configuration allows the metal to flow easily, more cavities than indicated can be expected.

The economics of the situation involve the balance of certain cost fundamentals. As the cavities increase, the per-piece price of the castings tends to decrease. However, in making the pattern, the more cavities introduced, the higher the pattern cost. For a given casting requirement, the increase in pattern costs must be offset by the decrease in the per-piece price of the castings because of the introduction of more cavities. An example will serve to illustrate this economic consideration.

Considering sample part XX and assuming that 300 castings are required, suppose that the pattern to make one cavity costs $150.00 and that the introduction of each additional cavity costs $20.00. The size of the part limits the cavities to six. According to the evaluation already made on this part, each casting will cost $1.26 on the basis of 6 cavities. If we had considered four cavities, this cost would have been $1.50 per casting. The casting-cost saving is $.24 per casting, or $72.00 for the contract. The additional pattern cost for the additional cavities is $40.00. Therefore, it would definitely pay to have six cavities for this part.

Since the economics of the cavity consideration are dependent upon the pattern costs, a more comprehensive study of this subject will have to await development of pattern costs; however, in the meantime *Fig.* 10 will give good estimates of the cavity expectations.

The application of *Fig.* 10 can be illustrated by reference to sample part XX. The envelope at the parting-line plane is about 4.33 by 2.98 inches (allowing for tolerances). The block common to the 4.5 inch (top of table) and the 3.0 inch (side of table) dimensions gives the figure six as the amount of cavities to be expected at each molding.

Future Study

Conclusion: This study is only the beginning. A more complete study must include the following:

1. A method of evaluating the cost of the pattern (and core box) for the most economical cavity consideration.
2. An extension of data similar to that presented herein for aluminum alloys and (possibly) steel.
3. A method of appraising the cost of die, permanent mold, and precision investment castings for magnesium and aluminum alloys and the tooling costs pertaining thereto. This is especially important because quantity requirements make comparisons between sand castings and die, permanent mold, and investment castings imperative.

Recently a great deal of attention has been drawn to the shell molding method of producing castings; the method of evaluating presented herein could be readily converted to include that process.

It is believed that the plan outlined in this article is a good approach in evaluating the cost of castings. Management can expect decided benefits from the utilization of this approach to an old problem.

Design consultants can quickly and accurately evaluate a casting design in the embryonic stages of the design, thereby saving considerable design and detail drafting time in the event that the analysis indicates a more economical alternate method.

By analyzing the elements of evaluation, the designer will be guided in designing the most economically producible casting for a specific problem.

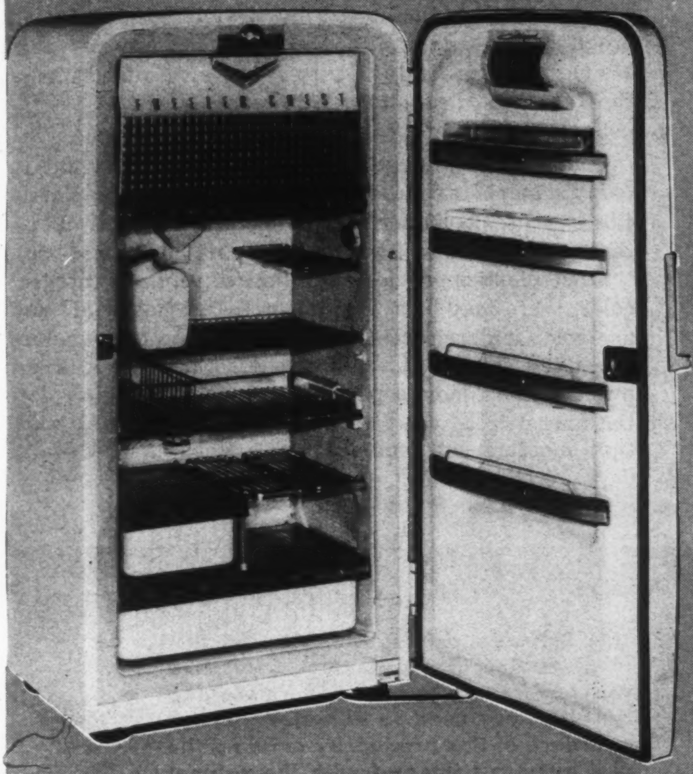
The cost estimating department will be able to rapidly predict casting costs with a degree of accuracy not possible by any other known method, thus assuring safe contract budgets.

The purchasing department will be guided in determining with which vendor to place an order. Fair pricing is mutually advantageous to the vendor and to the customer; the former makes a fair profit, the latter can expect reliable delivery schedules.

STYLING WITH PLASTICS

By Carl W. Sundberg and Montgomery Ferar

Sundberg-Ferar
Ferndale, Mich.



In this Coldspot refrigerator, the evaporator door was designed with a very rich textural effect by creating a pattern of spherical radii highlighted by metallic paint on the inside of clear polystyrene. The same effect was used on the handle, which is of acrylic plastic, and on the butter-keeper door, where the insulating properties of plastic help maintain proper temperatures. Also included in the comprehensive design for Seeger Refrigerator Co. were a cheese and bacon container of plastic and fitted plastic left-over dishes

TODAY, designers are faced with increasingly competitive markets. This increased competition can often be met by adding consumer appeal in the form of better styling, appearance, and function or use. Plastics, as versatile engineering materials, have certain inherent advantages in this respect and, at the same time, in meeting the requirements of good engineering practice.

Several merchandising features can also be added by plastics. Among them are sleek appearance — equipment that lives up to promotion claiming "latest modern design," "rich colors," "lustrous finish," and "handsome styling." This fine appearance, combined with warmth of touch and eye-catching color, make products highly appealing on display, and tend to develop a pride of ownership which can eventually lead to additional sales. Thus, it is easy to understand the great appeal of plastics to the industrial designer, and his tendency to employ them freely both in the development of new products and in the restyling of existing lines.

Plastics have already proved their worth in styling component parts such as dials, handles and knobs, and more important still in housings—protective and decorative shells which give machine equipment a clean, modern, efficient look and at the same time safeguard the mechanical parts of home or business-machine units.

Many factors influence the use of plastics for machine components. Design for appearance can never be completely separated from the engineering aspects of the product. But there are perhaps six distinct points in appearance design which must be considered in every application, and which must also be keyed into the engineering factors involved. Specifically, these are:

1. Size
2. Shape
3. Color
4. Texture
5. Decoration
6. Contrast

A brief study of these points may help in the efficient use of plastics as a styling medium.

Size and Shape: In designing machine housings, both size and shape are governed to a great degree by the product itself. Seldom can any great control be exercised over the mechanical elements in a mechanism. Nearly always the shape is fixed, around which the housing must be planned. While the physical size must, therefore, closely conform to the product to be housed, the impression of size of the product can be substantially altered by a number of design devices. A change in the relationship in height, breadth or thickness, and the careful use of color and decoration, can actually serve to make a product appear either larger or smaller than it actually is.

The shape of a well-designed housing should be functional—a shape which contributes to easy operation and use of the machine. Shape can also contribute merchandising appeal. Because plastic parts must conform to certain requirements in order to be moldable, they automatically assume the pleasing streamline effects so popular today.

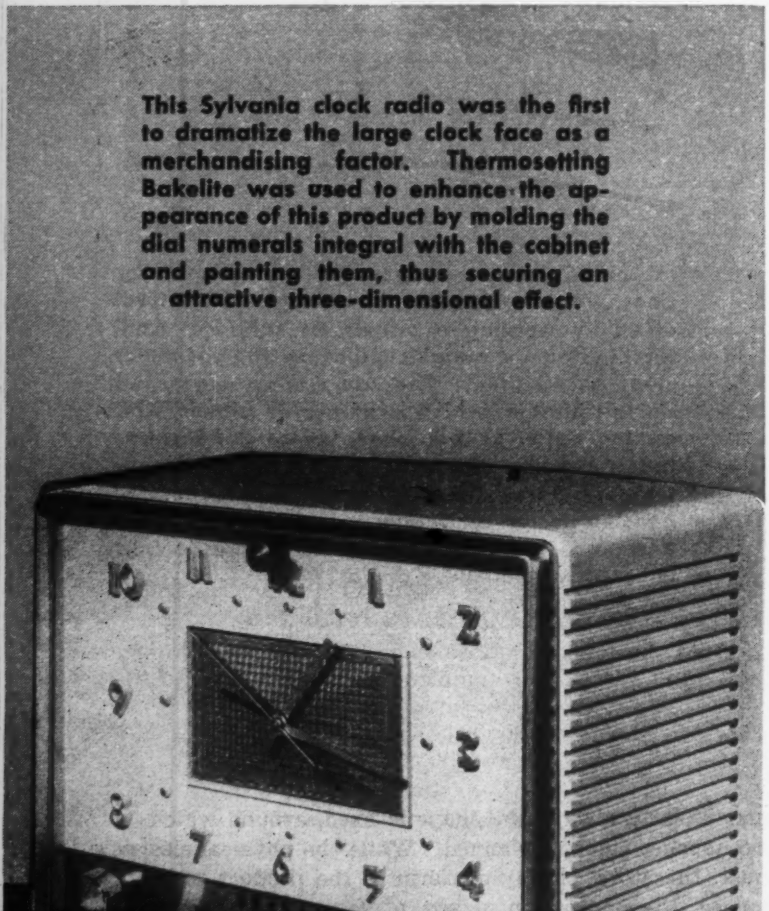
For economy in production, all molded parts should have a certain amount of taper so that they may be easily removed from the mold cavity. Thus, molding can be further facilitated by designing parts with broad curves and radii. Such sections are not only easier to mold but look better and give added structural strength to the part.

Color: Color is becoming increasingly important in today's markets, and quite often the use of a plastic can increase consumer acceptance of a product. Plastics offer color that is an integral part of the material.

Since plastics provide an unlimited range of integral color, there may be a temptation to "go hog wild" and use color indiscriminately. Actually, too many colors offset the balance of a design. Also, because it is not practicable to mold a part in more than a single color, the unrestricted use of color in design can entail multiple molding and increased assembly costs. Usually two colors carefully combined will yield the most interesting and effective results. Colors should be selected to harmonize with the surroundings in which a product may be expected to be used.

In some instances where heat resistance is an important factor, range of color is sometimes limited. At normal temperatures, thermoplastics with an almost unlimited range of color may be used. When temperatures do not exceed 180 F, certain heat-resistant plastics may be indicated. But above this temperature, the selection is somewhat limited. Certain thermosetting materials, such as the phenolics, have adequate heat resistance, but a rather limited color range. Others, with a broader color range, may have this advantage more than offset by higher material and production costs.

In one respect—that of resistance to impact—plastics offer several definite color benefits. Actual impact strength of plastics varies greatly, and plastics can be selected with adequate strength for most applications. But the integral coloring of plastics becomes of great importance when damaging impact occurs. A blow that might dent, chip or mar the decorative finish will often do no permanent harm to most plastics.



This Sylvania clock radio was the first to dramatize the large clock face as a merchandising factor. Thermosetting Bakelite was used to enhance the appearance of this product by molding the dial numerals integral with the cabinet and painting them, thus securing an attractive three-dimensional effect.

Texture: One of the most important features of plastics is their ability to eliminate finishing problems. A properly designed plastic housing emerges from the mold with its final texture and finish, requiring at the most a simple buffing operation.

Many manufacturers are yet unaware of the great variety of textures and finishes which can be obtained by special mold treatments or through the selection of the right plastic material. Special effects, such as wood, leather or pearl, can be simulated with plastics. The possibility of obtaining a variety of different textures is also offered by the plastic mold. Some of the most simple and economical methods involve knurling, sandblasting, and engraving.

A corollary advantage of plastics is their warmth and comfortable feel, particularly when used as knobs or handles. Both color and feel are provided by plastics in a degree that cannot be equalled by metal.

Decoration and Contrast: Contrast can be provided in a design by the effective combination of colors, by varying textures, or by combining plastics with metal or other materials. A metal band very often will not only supply contrast, but at the same time serve to hide joints or parting lines and give added structural strength. Supplementary decoration can be obtained at comparatively little cost by engraving or embossing decorations in mold cavities.

One place where decorations may have to be used is on large plane surfaces. Large plane surfaces are difficult to mold. Sink marks will often be present and it is difficult to maintain a consistently good finish. Broad curved areas are more pleasing to the eye, seldom require supplementary finishing, and are therefore preferable. If a large plane surface seems to be unavoidable, however, it can be effectively broken up by a decorative design that will help to hide flow marks and produce a more pleasing effect.

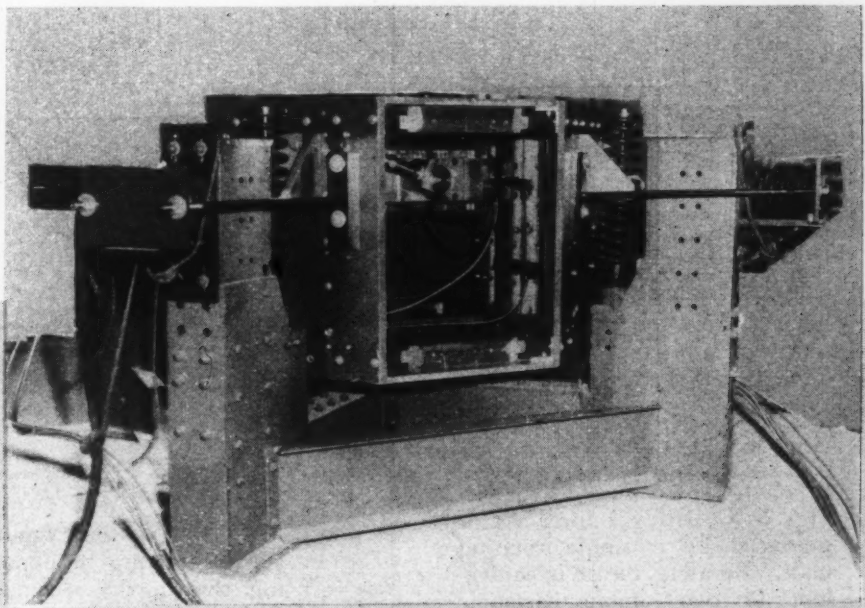


Fig. 1—Vibration table driven by a directional mechanical oscillator. Built for the Armed Forces, this machine permits controlled vibration testing of relatively large equipment. Photo, courtesy Buck Engineering Co.

By Rudolf K. Bernhard
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Three-Mass Space Oscillator

Unique mechanism employs revolving weights to generate controlled vibrations

ONE OF THE simplest machine elements known is the eccentric weight revolving about a shaft. It produces a centrifugal force with a magnitude proportional to the weight, to the eccentricity, and to the square of the speed. Practical uses of this force are many, and include counterbalancing other forces, vibrating screens and conveyors, compacting solid materials, vibration testing, and so forth.

Limitations of this simple one-mass mechanical oscillator, as it is called, are its two-dimensional or rotating characteristics and the fact that the force magnitude varies as the square of speed. The mechanism discussed in this article is a three-mass oscillator with variable eccentricities which can be controlled so as to give a periodic force of constant amplitude independent of frequency, in any direction and in one, two or even three dimensions. A practical machine employing the principle is illustrated in *Fig.* 1. The mechanism, with its controls, can be applied in many places to improve the operation of machines, such as already mentioned, which depend to greater or less extent on the creation of periodic forces.

Principles and Construction: Understanding of the design factors in engineering a mechanical oscillator will be aided by a brief analysis from the simple one-mass unit through the two-mass oscillator and finally to the more complex three-mass mechanism. A single mass, m pound-second^2 per inch, rotating at a speed of ω radians per second with its center of gravity at eccentricity e inches produces a centrifugal force F which is given by

$$F = me\omega^2 \qquad (1)$$

The force vector rotates, but may for convenience be regarded as equivalent to two linear periodic forces acting along mutually perpendicular axes, *Fig.* 2. If only one linear force is desired, special guides or planetary gear trains are necessary.

A two-mass oscillator is simply a pair of masses on parallel shafts rotating at equal speeds in opposite directions. When equal and in proper phase, the two masses can be made to excite a resultant linear periodic force, R, as shown in *Fig.* 3. The resultant force, R, is given by

$$R = 2F \cos \omega t \qquad (2)$$

Such a system is employed on General Motors diesel

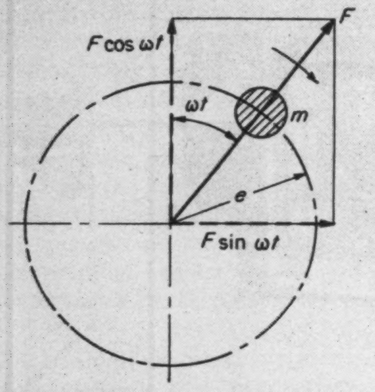


Fig. 2—Centrifugal force vector produced by a single rotating mass. Rotating vector is equivalent to two simple harmonic forces acting in straight lines at right angles to each other

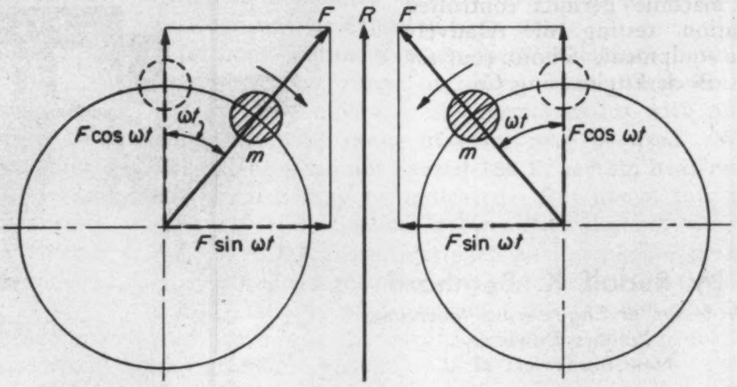


Fig. 3—Two-mass mechanical oscillator with equal masses rotating in opposite directions. With the phasing shown, the x-components always cancel each other, leaving a simple harmonic force along the y-axis only. Change in phase changes the location and direction of the resultant

engines to counterbalance the primary reciprocating forces caused by the motion of the pistons.

The three-mass oscillator with which this article is primarily concerned is illustrated in principle in *Fig.* 4. The masses are attached to equally spaced parallel shafts of which the center shaft rotates in the opposite direction to the two outer shafts.[1, 2]

The resultant force at any instant can be found graphically or analytically by taking summations of forces and moments. Its line of action is situated at some distance ϵ from the center of the middle shaft. In special cases ϵ can be zero.

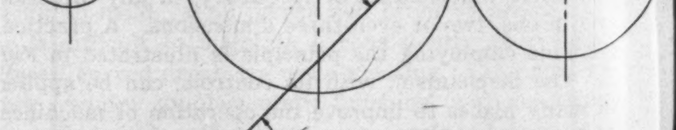
Eccentricities and phase angles of these masses can be varied independently as indicated schematically in *Fig.* 5. Actual construction of the eccentricity-shifting mechanism is shown in *Fig.* 6 and of the phase-shifting mechanism in *Fig.* 7. The three rotating masses of the oscillator are visible in *Fig.* 8. In the foreground are the eccentricity-control servomotors.

Controls: In order to produce constant force or moment-vectors, regardless of the frequency, the three unbalances m_1e_1, m_2e_2 and m_3e_3, *Fig.* 4, must vary inversely with the square of the frequency. This has been achieved by a speed-responsive device connected to the eccentricity control in such a manner that the distances e_1, e_2, and e_3 vary inversely with the square of the frequency. A centrifugal-force governor can be used for this purpose, since the vertical distance between the two rotating weights of the governor and their suspension point changes in inverse proportion with the square of the angular velocity of the weights.

SERVOMECHANISM. The three eccentricities (e_1, e_2, e_3) and the two phase angles ($\alpha-\beta$ and $\gamma-\beta$) of the rotating masses (*Figs.* 4 and 5) can be remotely controlled, independently and automatically, while the oscillator is operating, by means of five almost identical electromechanical servomechanisms. These mechanisms are able to follow any type of analytic function such as required for eccentricity and phase control.

A block diagram of one of the five control units is shown in *Fig.* 9. Five pairs of linear differential transformers[3] represent the transducer of a repeater system for any type of continuous linear motion. Three pairs of matched transformers control the eccentricity shifts; two similar pairs control the phase shifts of the oscillator. One transformer of each pair (sender)

Fig. 4—Three-mass mechanical oscillator, shown in the momentary position of maximum resultant force, *R*. Rotation of the three masses in the indicated directions causes *R* to diminish in magnitude though still acting along the same line. After 90 degrees rotation the resultant is zero; after 180 degrees it is again maximum but pointing in the opposite direction



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[1] References are tabulated at end of article.

THREE-MASS SPACE OSCILLATOR

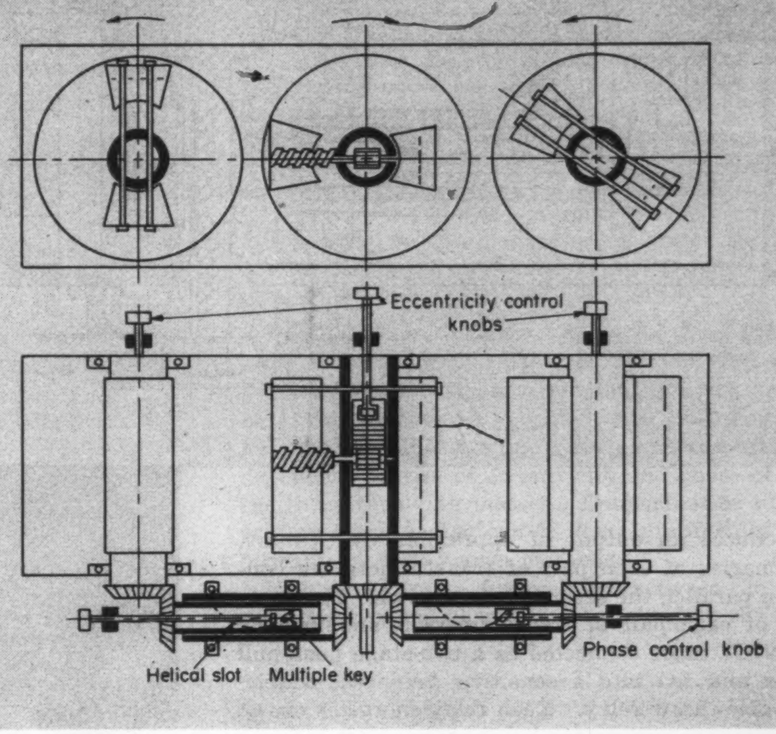


Fig. 5—General arrangement of a three-mass oscillator with means for independently controlling the eccentricities and phase angles of each mass

is on the control stand; the other (repeater) is fixed on the oscillator.

The secondaries of each transformer pair are connected electrically in such a manner that an error voltage is produced as soon as the positions of their cores with respect to their fields do not coincide. This error voltage is proportional to the relative change in transformer core position. On the control stand the position of each core is governed by five interchangeable cams, which are rotated by a governor. This governor is driven by a belt from the shaft of the main oscillator motor. Form and rotational speed of the five cams correspond to the required rate of change in eccentricity and in phase of the three-mass system. On the oscillator, each core is connected by a rack and pinion drive to one of the five output shafts governing eccentricity and phase. These shafts are driven by individual servomotors via a worm reduction which acts simultaneously as a damping unit. The oscillator is seen in the foreground of *Fig.* 8, with the control stand behind.

For each transducer a core displacement of ±0.001-

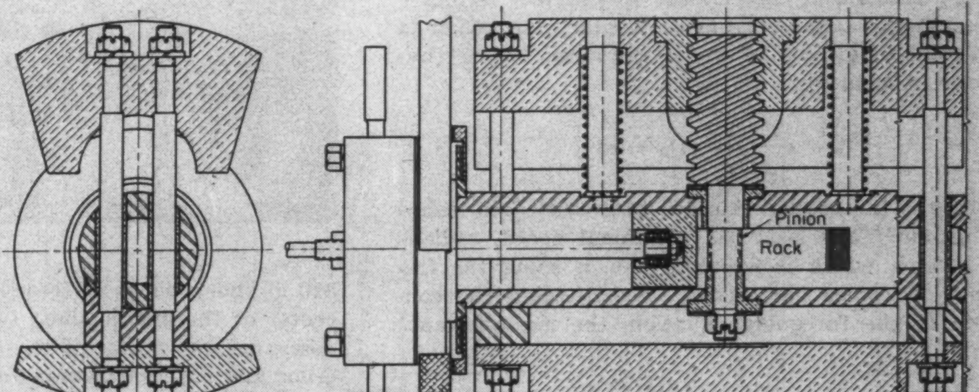


Fig. 6—Detail of eccentric masses and mechanism for controlling eccentricity

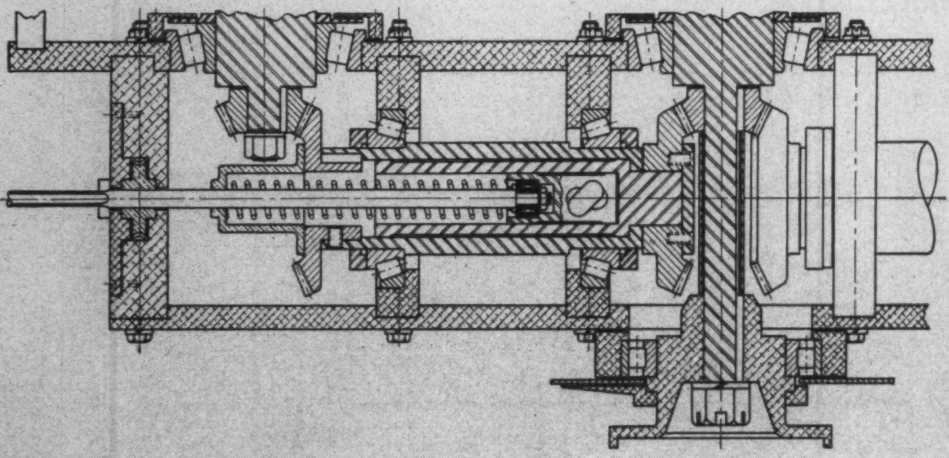


Fig. 7—Left—Mechanism for adjusting phase angle between middle weight and end weights of three-mass oscillator

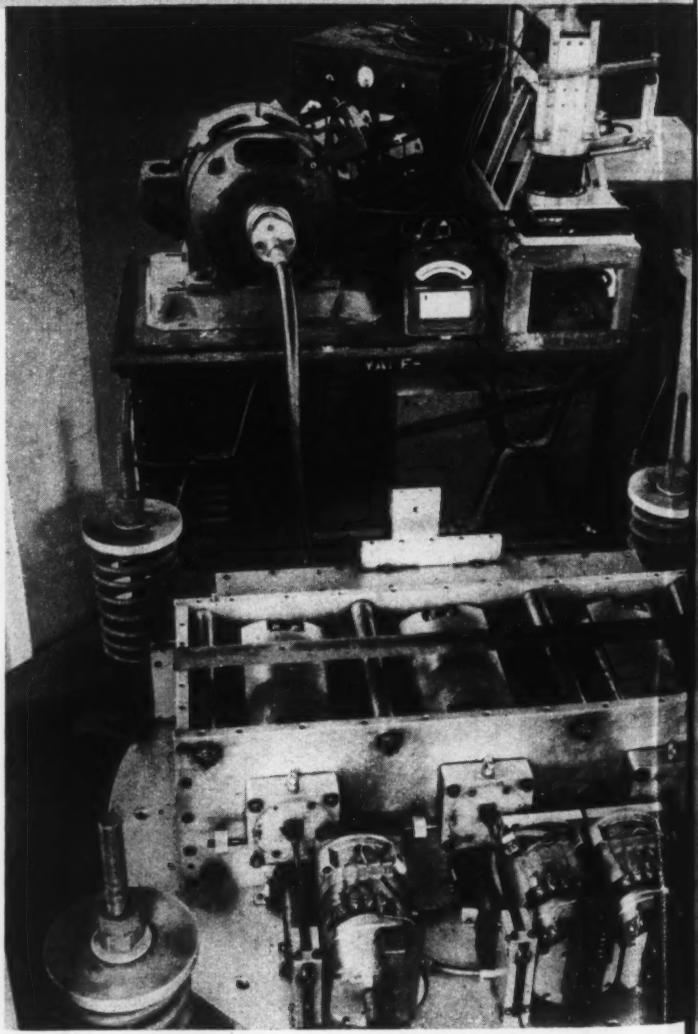


Fig. 8—Below—Experimental three-mass oscillator with cover removed. Servomotors for eccentricity control are in the immediate foreground, each with its differential transformer alongside. In the background is the control stand, with main drive motor at left, amplifier in the middle, and "camtroller" with governor at right

inch produces an output of approximately ±8 mv. The primaries of each pair of transformers are connected in parallel, the secondaries in series. The error voltage of each pair of transformers is amplified by two 6SN7G7 tubes connected as a two-stage push-pull amplifier and fed into a sensitive, balanced, double-pole, double-throw relay. Each relay energizes one of the servomotors, which rotate either forward or backward as long as the positions of the two corresponding cores do not coincide. Hence these output motors repeat the motion of the input cores, that is, produce the required changes in magnitude, direction and action line of the resultant force or moment vector.

When testing conditions subject the oscillator continuously to strong vibrations or large temperature changes, the servomotor outputs can be connected by flexible shafts to the corresponding load shafts on the oscillator. Hence servomotors, worm gear drives and transducers may be placed on the control stand.

CAM CALCULATIONS. As an example of the calculations and cam design required, the machine shown in *Fig.* 8 has equal masses on all three shafts. The larger mass on each shaft weighs 17 lb and the smaller 8 lb, their centers of gravity being 4 11/16 inches apart. Considering the middle weight and letting e represent the distance from the center of rotation to the center of gravity of the larger mass, the net unbalance is equal to

$$\left[\frac{17}{g}\,e - \frac{8}{g}\left(4\tfrac{11}{16} - e\right)\right]\omega^2$$

where g is the acceleration due to gravity, 386 inches per second^2; and ω is the rotational speed, radians per second, which is equal to $2\pi n$, n being the frequency in cycles per second. Substituting the constants in the foregoing equation, the net unbalance becomes

$$(2.54e - 3.81)\ n^2$$

where e, the eccentricity, can have different values at each of the three shafts.

Assume it is desired to produce a periodic resultant force vector R (*Fig.* 4) of maximum value equal to 540 lb, independent of frequency, passing through the center of the middle shaft ($\epsilon = 0$). It is necessary to determine the profile of the cam which links the governor and differential transformer (*Fig.* 9) so that as frequency n varies, the eccentricities of each mass will be adjusted to maintain constant R. Reference to *Fig.* 4 will show that if R is to maintain constant direction and pass through the center of the middle shaft, the unbalance at each end shaft must equal one-half of that at the middle shaft. Then the total force vector will be twice that produced by the center mass alone, or

$$R = (5.08e_2 - 7.62)\, n^2 \quad \ldots\ldots (3)$$

This gives the desired relationship between e_2 and n. Substituting $R = 540$ lb and solving for e_2

$$e_2 = \frac{106.2}{n^2} + 1.5 \quad \ldots\ldots (4)$$

The cam follower which operates the linear transformer should move with this relationship as n changes. However, the cam is rotated by a governor having the characteristics shown in *Fig.* 10. Combining Equation 4 and *Fig.* 10 gives the required cam form for this particular governor and the requirements of the problem, *Fig.* 11.

Control range of the governor can be adapted to the required frequency band by adjusting the preload of the governor, that is, changing spring constant and/or weight with respect to position and magnitude, *Fig.* 10.

This electromechanical servomechanism as applied to the three-mass oscillator may be adapted with only minor changes to any mechanical oscillator with one or more unbalances. However, two prerequisites have to be kept in mind:

1. The complete vibrating system including the exciter mass, i.e., the mechanical oscillator and the excited mass, has to be rigid enough to transmit forces and moments undistorted.
2. To produce a pure linear motion, the action line and the direction of the exciting force vector are fixed. In other words, the exciter force has to pass through a point, the "dynamic elastic center". The position of this point depends upon the natural and exciter frequencies, the elastic supports, and the damping of the vibrating system.[4]

Possible Force Vectors: With the three-mass oscillator a considerable variety of periodic forces can be produced—either linear (one-dimensional) or revolving (two-dimensional), with action lines controllable within reasonable limits. This is effected through independent control of eccentricity and phase of each of the three revolving masses. Determination of the resultant force vector can be done graphically or analytically by well known methods.

FORCE ANALYSIS. Interrelation between the variable eccentricities and phases is determined by the solution

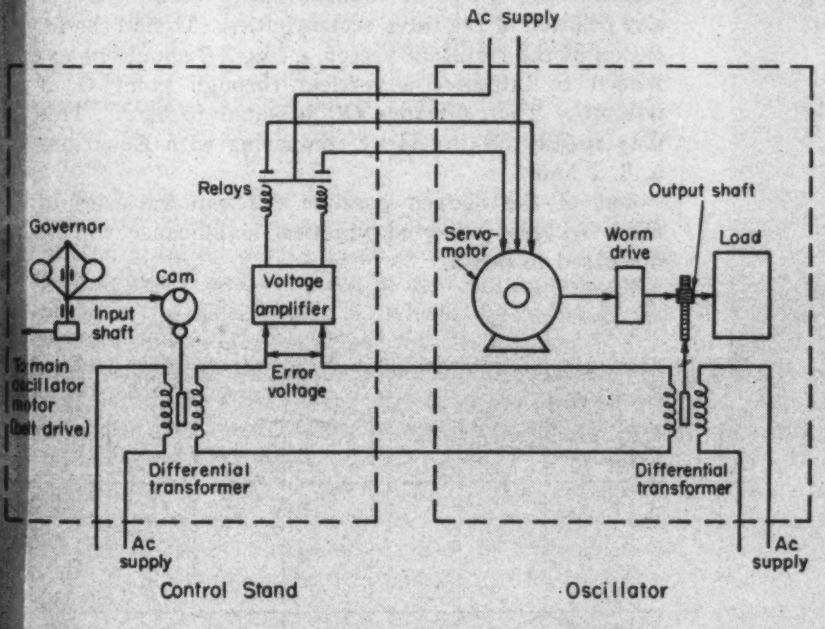


Fig. 9—Left—Block digram of electromechanical servomechanism for automatic eccentricity control of a mechanical oscillator

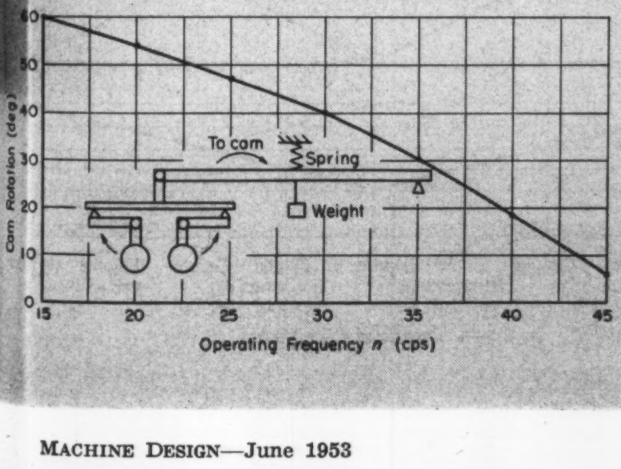


Fig. 10—Left, below—Relationship between cam rotation and operating speed for centrifugal governor

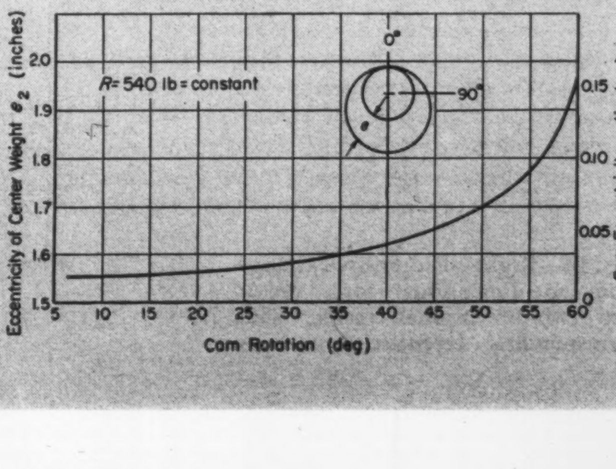


Fig. 11—Below—Cam eccentricity required to provide a constant maximum resultant force independent of frequency for mechanical oscillator

of four simultaneous equations established by summation of forces and moments. Analysis is simplified by the fact that the three masses are equal so that the force vectors are directly proportional to the eccentricities, *Fig.* 4. Also, when the resultant is maximum the direction of the eccentricity of the center mass is parallel to the line of action of the resultant, $\beta = \theta$; finally, the maximum value of the resultant is proportional to twice the eccentricity of the center mass; numerically $R_{max} = 2e_2$. Using these factors, equations can be set up for the summation of forces parallel and perpendicular to the line of action of the resultant when R is maximum, and for the summation of moments when R is maximum, and when R is minimum ($R_{min} = 0$ when the masses have rotated 90 degrees from the R_{max} position). After rearranging and combining, the four equations become

$$2\,\frac{e_1}{e_2}\sin(\alpha - \beta) = 4\,\frac{\varepsilon}{d}\cos\theta \qquad (5)$$

$$2\,\frac{e_3}{e_2}\sin(\gamma - \beta) = 4\,\frac{\varepsilon}{d}\cos\theta \qquad (6)$$

$$1 + 4\,\frac{\varepsilon}{d}\sin\theta = 2\,\frac{e_3}{e_2}\cos(\gamma - \beta) \qquad (7)$$

$$1 - 4\,\frac{\varepsilon}{d}\sin\theta = 2\,\frac{e_1}{e_2}\cos(\alpha - \beta) \qquad (8)$$

For an actual mechanism, d is fixed; in a particular application θ is known (and $\beta = \theta$), hence the four unknowns are e_1/e_2, e_3/e_2, α and γ.

A graphical solution based on the foregoing equations is illustrated in *Fig.* 12. The sides of triangle *OAB* represent in magnitude and direction the three eccentricities when resultant R is maximum (compare with *Fig.* 4). It should be noted that to satisfy the conditions established the triangle must close and a vertical through point B must bisect vector OA for any position of the three eccentricities. To find the location of the resultant vector, ε, line AB should be extended to intersect a vertical through point O at point C. Then distance OC is equal to $4\varepsilon/d$. This may readily be proved by comparing with Equations 5, 6, 7 and 8.

Out of the sixteen possible different varieties of force vectors, a few of practical significance will be discussed in detail.

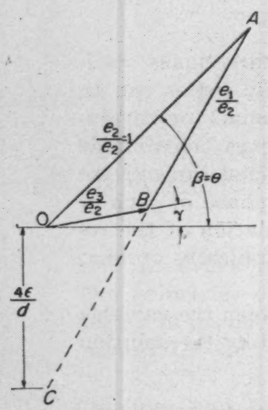


Fig. 12—Left—Vector diagram solution for problems with a three-mass mechanical oscillator producing linear force vector. Compare with *Fig.* 4

Fig. 13—Below—Two-dimensional force vector. With fixed phase angles, the locus of the centrifugal force vector is an ellipse stationary in space. With continuously varying eccentricities, the ellipse can be made to rotate

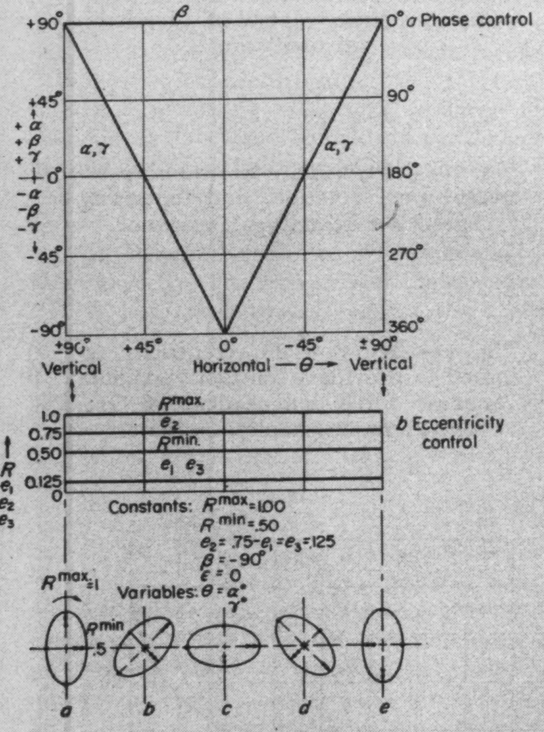
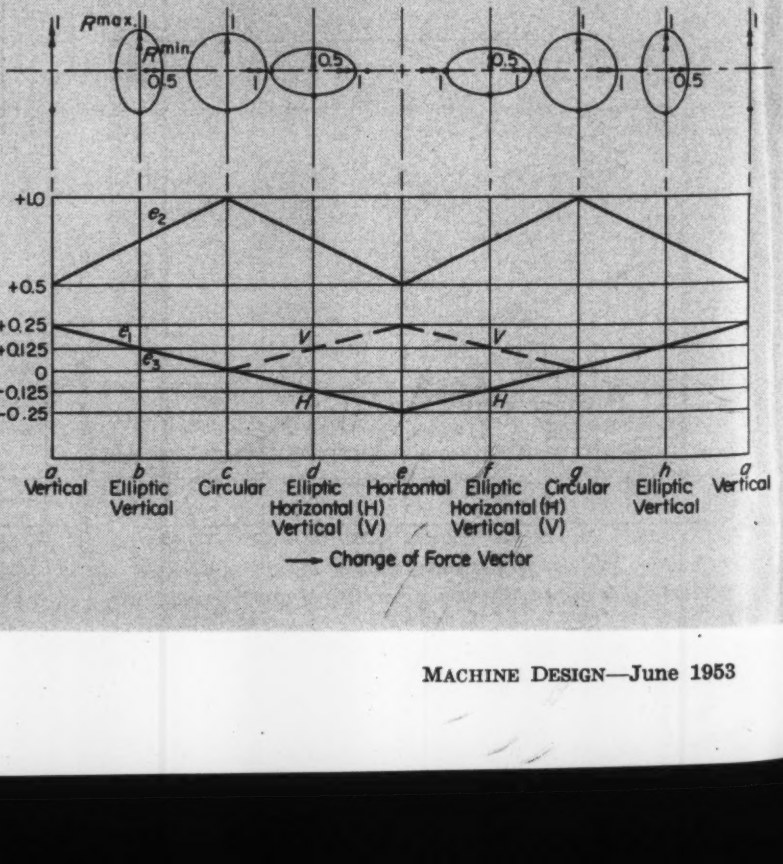


Fig. 14—Right—Progressive change from one-dimensional force vector into two-dimensional vector, with corresponding eccentricity changes



Linear Force Vectors. Often a straight-line periodic force is desired, such as the two-mass oscillator can produce, *Fig.* 3, but with line of action in a desired direction and location. An example is shown in *Fig.* 4 with the corresponding graphical solution in *Fig.* 12, the line of action being directed at an angle of 45 degrees to the horizontal and at a distance $0.145d$ from the middle shaft center. The mechanism is shown in phase for maximum resultant. After 90 degrees of shaft rotation, the resultant is zero; 180 degrees later R is maximum again but in the opposite direction.

If it is desired to create a resultant of the same magnitude and direction but with a different eccentricity ϵ, changes must be made in eccentricities and phase angles e_1, e_3, α and γ. A few examples are indicated in the first four lines of Table 1.

Alternatively, it may be desired to maintain the resultant at its maximum magnitude R_{max} and eccentricity ϵ but to change its direction θ. Solution for $\theta = 0$ and $\theta = 90$ degrees are indicated in the fifth and sixth lines of Table 1.

Two-dimensional Force Vectors. A two-dimensional, rotating force vector of constant magnitude is created by the simple one-mass system shown in *Fig.* 2. With a three-mass system it is possible to create a rotating force vector which changes in magnitude as it rotates, in an elliptical manner, that is, R is maximum in one direction and minimum in a direction at right angles. This is illustrated in *Fig.* 13, for $R_{max} = 1$ and $R_{min} = 0.5$. To create this condition $e_2 = 0.75$ and $e_1 = e_3 = 0.125$. Orientation of the ellipse is determined by the phase angles α and γ, as indicated on the graph above the illustration of five ellipses.

With phase angles fixed at any one of the values indicated in *Fig.* 13, the ellipse indicating the locus of the rotating vector remains stationary in space. If the phase control, through use of a suitable cam, changes the phase angles periodically according to the relation in *Fig.* 13, the ellipse rotates in space.

Another possible vector is one which changes from a circular (constant) force through an elliptical form to a straight line. *Fig.* 14 shows the necessary relationships for accomplishing this.

In all cases such as described previously or in cases of similar character, the resultant centrifugal force vector, R, remains constant, rotates, or changes periodically in frequency, magnitude, direction, or action line.

The resultant force vector will be either one or two-dimensional if the eccentricity and phase control units follow the required curves for the eccentricity vectors: e_1, e_2, and e_3, and phase angles: $\alpha-\beta$ and $\gamma-\beta$. These curves are smooth, that is, without abrupt changes, hence can be reproduced by simply inserting the corresponding cams into the servomechanism.

It has to be kept in mind, however, that any variations of the resultant motion caused by resonance or coupling effects due to changes in the dynamic characteristic of the vibrating system have to be considered, regardless of whether these effects are intentional or accidental. Variations in the elastic or damping constants of the vibrating system, for example due to the development of fatigue cracks in the cross-section of a specimen, may cause such changes.

Table 1. Typical Settings of Mechanical Oscillator

Resultant			Rotating Weights			
Magnitude	Direction*	Eccentricity	Eccentricities		Phase angles*	
R/e_2	θ	η/d	e_1/e_2	e_3/e_2	α	γ
1	45	0	0.50	0.500	—45	45
1	45	0.145	0.35	0.745	—10	61.5
1	45	0.291	0.40	1.000	33	69
1	45	0.550	0.55	1.000	65	76
1	0	0.437	1.00	1.000	60	—60
1	90	0.250	0	1.000	—	90

*Degrees.

Applications: Several fields of application for mechanical oscillators have already been mentioned. A number of directional oscillators of the type here discussed have been built so far. All are operated by remote control, the control cabinet being located about 20 feet from the machine. Applications where the characteristics of this machine have been particularly valuable include vibration testing and soil compacting.

In calibrating a seismometer on a vibration table it was of primary importance to adjust the force vector produced by the oscillator in such a form that a pure linear motion through the center of gravity of the seismograph could be produced.

A large vibration table driven by a directional oscillator is shown in *Fig.* 1. Built for the Armed Forces, this machine differs in two major respects from previous machines: the control motors are enclosed in the control cabinet, not on the machine, to permit operation of the machine under extreme temperatures; and the oscillator is rotatable around a horizontal axis. This rotation around a longitudinal axis while in operation produces an automatically cycling three-dimensional space oscillator.

An experimental dynamic soil compactor employing an oscillator has been developed at the Bureau of Engineering Research of Rutgers University. It has been used to compact or densify the subsoil in highway construction, and can be made self-propelling through proper control of vector magnitude, direction and location. Thus by making the vertical component large enough to lift the unit a small amount from its support while the horizontal component exerts simultaneously a forward thrust, the machine can "leap-frog" and thus cover large areas of soil. It will even climb a 20-degree slope in this manner. When used as a dynamic soil compactor the oscillator is subjected to strong impact blows. Regardless of this severe punishment, only minor repairs to the oscillator have been necessary in five years of operation.

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3. H. Schaevitz—"The Linear Variable Differential Transformer," *Experimental Stress Analysis*, Vol. 4, No. 2, Page 79, 1947.
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Redesign for Economy

Design simplifications for improved service life and assembly effects substantial cost savings through reduced machining, fewer parts and faster production

By Clare Holt
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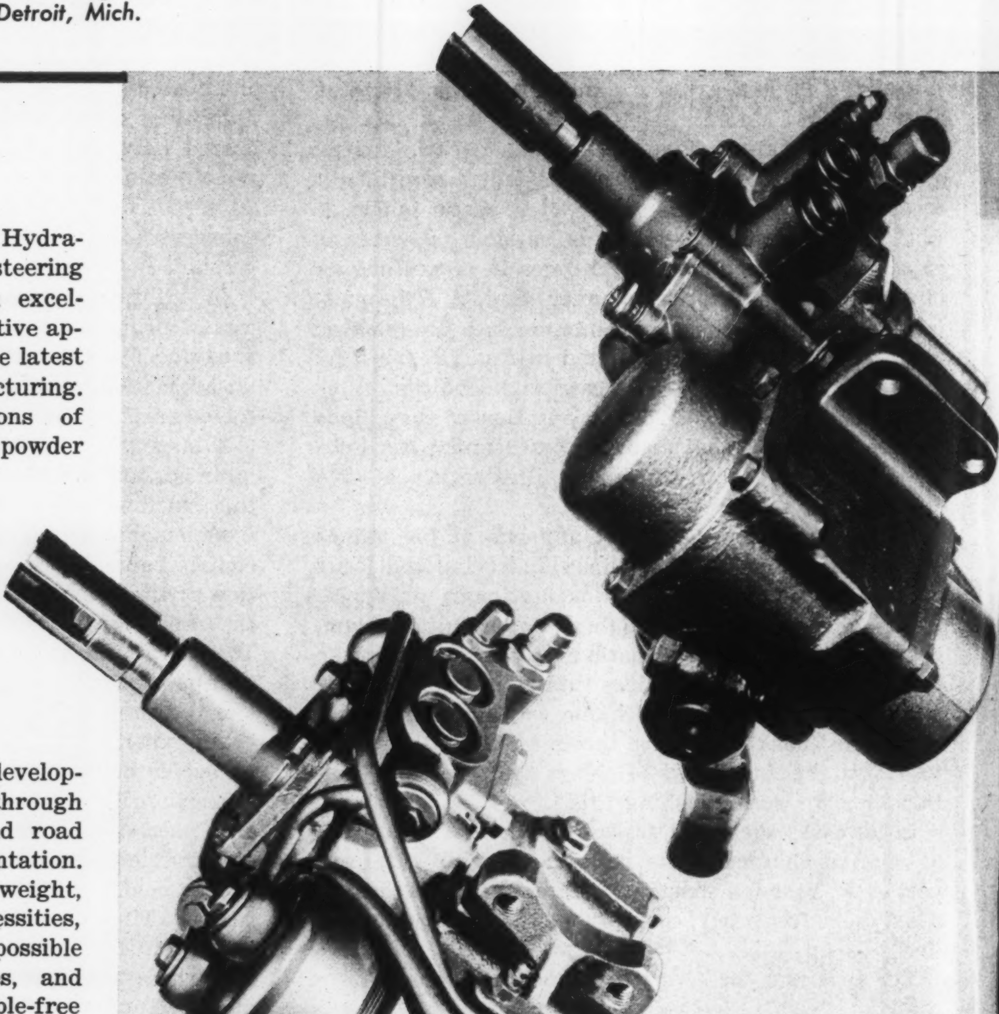
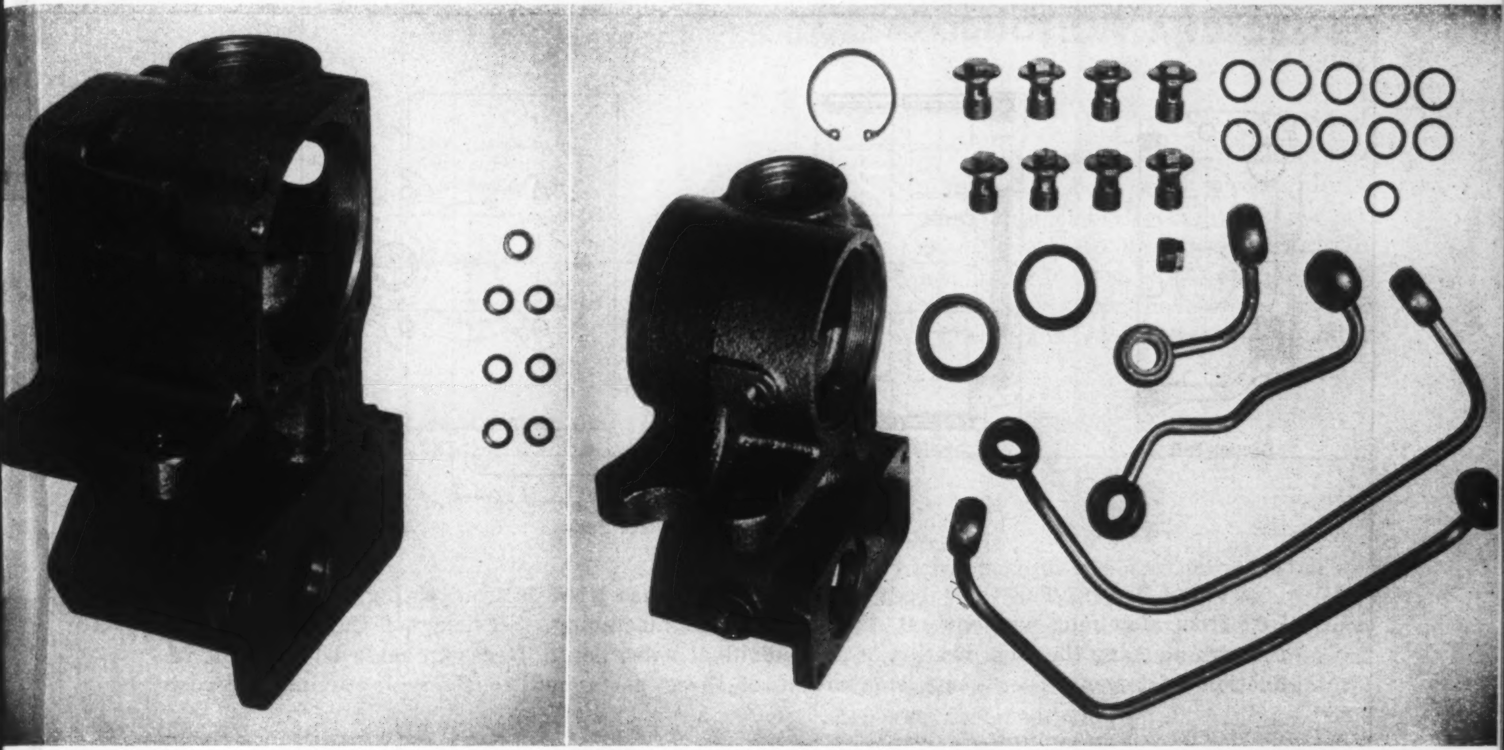
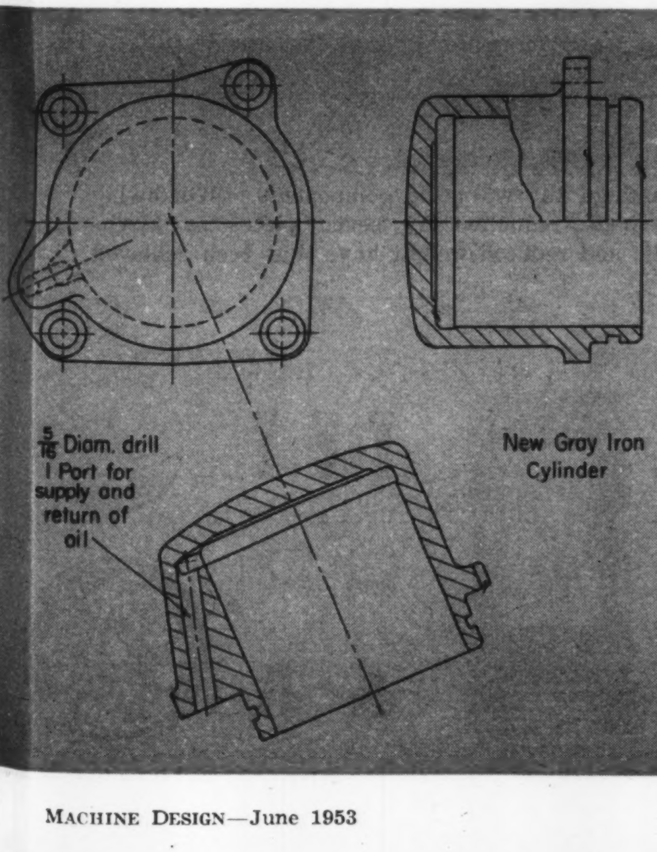
REDESIGN of the Hydraguide power steering gear provides an excellent example of the effective application of several of the latest developments in manufacturing. Through the innovations of aluminum die casting, powder metallurgy, injection-molded plastics and sand-cast aluminum, economies have been effected in manufacture, machining and assembly along with improvements in design. Successful application of these extensive design developments has been verified through stress investigations and road and laboratory experimentation.

Cleaner lines, reduced weight, simplified service necessities, with fewer points of possible operational discrepancies, and thus longer, more trouble-free life has been achieved in this redesign for production. The overall number of parts has been reduced by thirty pieces with appreciable savings in machining, assembly and manufacture. A total weight reduction of over twenty-five per cent has been effected.

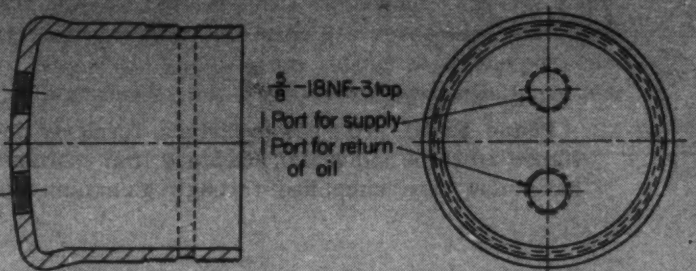




Housing: Formerly a malleable iron casting, the housing is now manufactured of cast aluminum. The distribution and transfer of oil to and from the power cylinders, formerly accomplished through steel tubing and fittings, is now done by means of passages cored internally in the castings, thus eliminating all exterior oil lines and several possible sources of oil leakage. Furthermore, the use of grease as a worm gear lubricant has been eliminated. The hydraulic oil serves the dual purpose of lubrication and power medium, making possible elimination of two oil seals and further simplifying assembly. The use of aluminum has effected a weight savings of fifty-eight per cent and enhanced production economies through the elimination of twenty-five component parts.

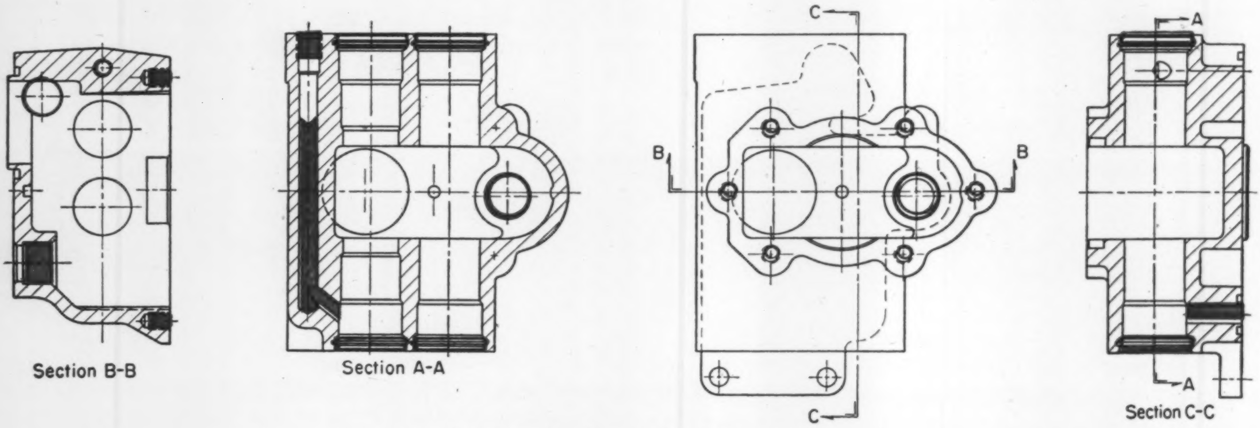

$\frac{5}{16}$ Diam. drill
1 Port for supply and return of oil

New Gray Iron Cylinder



Original Drawn Steel Cylinder

Cylinders: Formerly a drawn and threaded cup held in position with a lock ring, cylinder design is now high-strength gray cast iron utilizing a flange type construction. Thus, though the weight has increased seventy-five per cent and there are two more parts in the construction, attractive savings have been realized through part and assembly simplification.



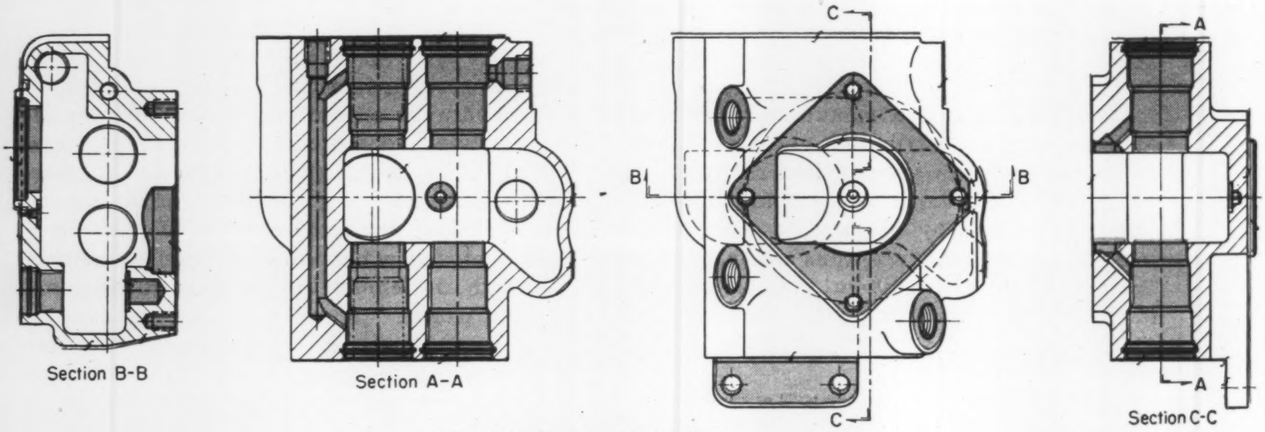
Section B-B

Section A-A

Section C-C

Die Cast Aluminum Valve Body

Valve Body: The valve body, previously machined from an iron casting, is now being die cast from aluminum with virtual elimination of all machining. Servicing of the gear is aided through marking the identification of the individual valve ports. Redesign achieved a weight reduction of seventy per cent, elimination of three parts and considerable savings in cost.



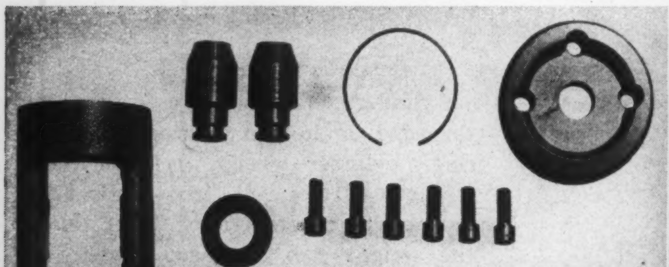
Section B-B

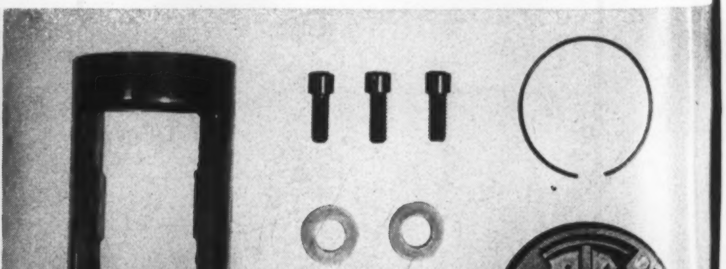
Section A-A

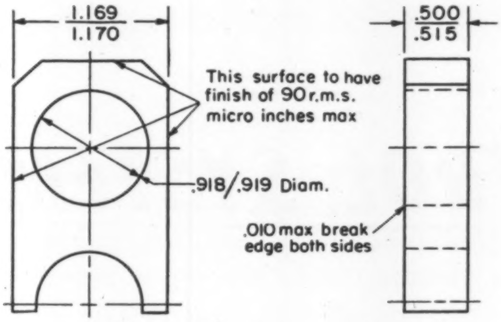
Section C-C

Original Cast Iron Valve Body

Piston Ends: The power pistons, formerly designed as three individual machined iron castings, have now been simplified through aluminum die castings to two basic components. Worthwhile savings, reduction by seven pieces in assembly, and reduced weight have thus been achieved.

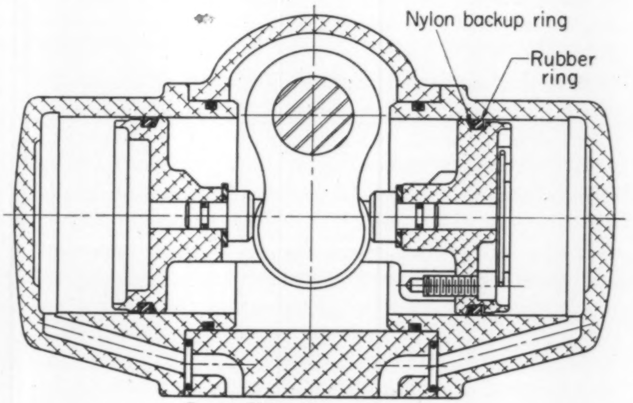





1.169
1.170
.500
.515
This surface to have finish of 90 r.m.s. micro inches max
.918/.919 Diam.
.010 max break edge both sides

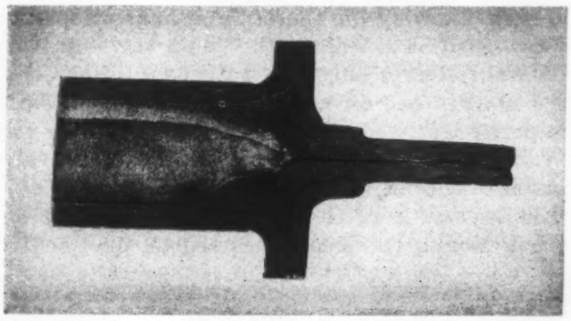
Powder Metal Valve Operating Block

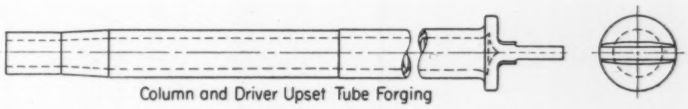
Valve Operating Block: Powder metallurgy has been used successfully to effect appreciable economy in this part as compared to its former design for machining from steel. The required machine operations have been greatly reduced and stock waste eliminated.



Power Piston Arrangement

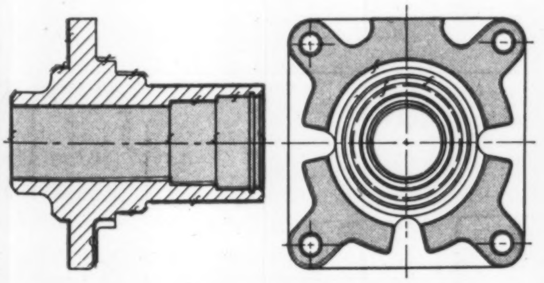
Piston Seal: In response to the need for a piston seal capable of withstanding the radial forces (240 pounds) exerted by the power piston, while preventing metal contact between the piston and cylinder wall and extrusion of the rubber section under high pressures, a special seal was designed and developed by Greene, Tweed & Co. The resultant design has a rectangular rubber section backed up with an injection molded nylon ring. Not only are the necessary demands met, but the seal enhances life, reduces friction and cost.





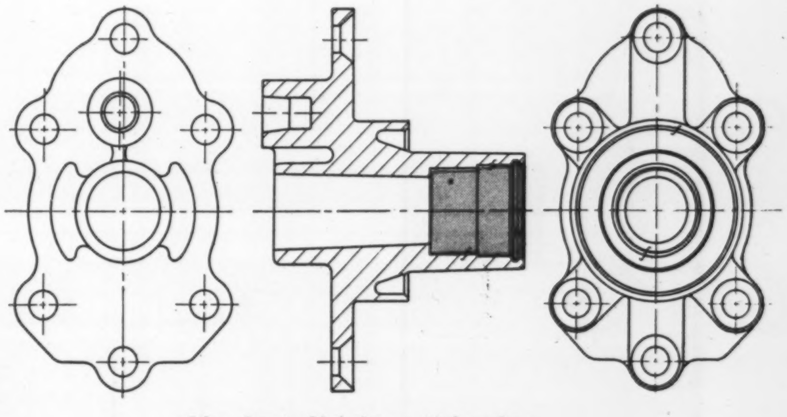
Column and Driver Upset Tube Forging

Column and Driver: This component, formerly manufactured of tubing butt welded to a machined driver, is now forged integrally from tubing as a one-piece design thus simplifying manufacture and lowering costs.



Malleable Iron Valve Cap

Valve Cap: Another application of aluminum die casting, virtually eliminating all machining required with the previous iron casting, is the valve cap. A weight reduction of seventy-five per cent, elimination of one part and corresponding economy resulted.



Die Cast Aluminum Valve Cap

HYDRAULIC CONTROL SYSTEMS

Part 3–Pilot and Electrical Control

FOR machines requiring high horsepowers, control of selectors by small pilot valves may be adopted because operating loads on the main valves are inconveniently high, because it is inconvenient to bring large-diameter pipes to the control position, or to reduce the length of the main pipe runs. Again, pilot control may be convenient for automatic sequence systems and for certain speed-control applications.

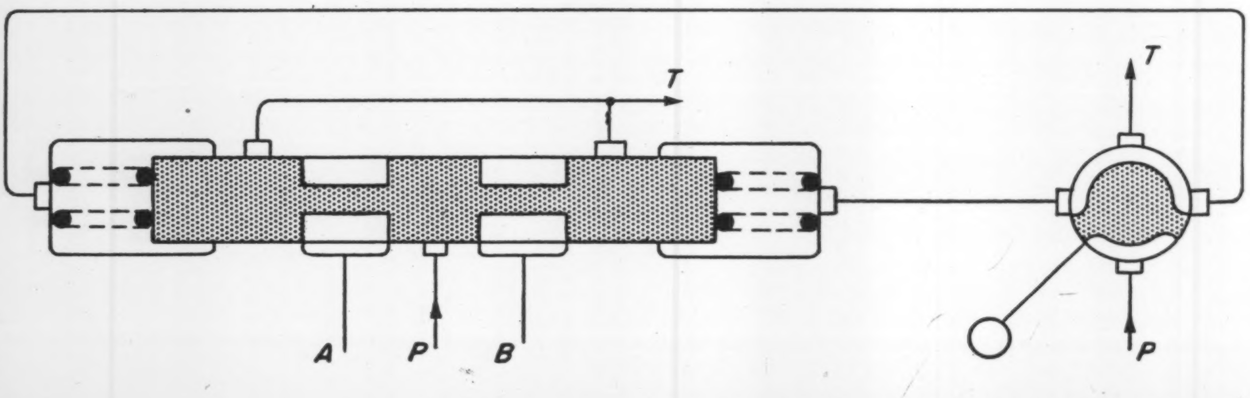
Similar considerations apply to electrical control of selectors and other valves, but with even greater emphasis. Hydraulics may be a good method of transmitting power, but for signaling or control purposes it is often inferior to electrical methods. The reason for this is twofold. First, even with pilot control the signaling lines (pilot pipes) still tend to be somewhat bulkier and more difficult to lay and to connect than electric signaling lines. Second, if complicated combinations of connections are involved, the pilot valves concerned are likely to be rather complicated, expensive, and cumbersome whereas with electric relays and other switchgear it is a minor matter to add a few more contacts.

Electrical control is certainly the most convenient solution in an automatic machine if the sequence is to be controlled on a time basis. On the other hand, electrical control may introduce an additional system with its attendant specialized maintenance and is sometimes disliked by operators on this account. In this article systems controlled by manually operated pilot valves or switches will be examined and discussed. Indirect control as applied to automatic sequence systems will be considered in the following article.

Pilot Control of a Single Selector: *Fig.* 91 shows a three-position (spring centered) selector controlled by a four-way three-position pilot valve. When the latter is in neutral, both control connections at the selector are to tank, allowing the centering springs to operate. With two-position selectors the pilot valve likewise need of course have only two positions. If the selector is biased in one direction by a spring or a small piston permanently connected to pressure, a three-way pilot valve is sufficient, or even a two-way pilot valve if resistance control is used, *Fig.* 53*a*, Part 1.

If the selector is of the two-position type and has "stay put" action (no bias or centering), pilot control

Fig. 91—Three-position selector controlled by a four-way three-position pilot valve



By R. Hadekel

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London, England

Basic design of machine hydraulic systems is put on a methodical and consistent foundation in this series of articles to aid development of circuits for maximum simplicity and effectiveness.

pressure need only be applied for a short period, say, a fraction of a second. In this case the pilot valve can take the form of a pair of spring-returned pushbuttons. *Fig.* 92 illustrates a system of this type using resistance control as applied to a seating valve selector with a locking device which cancels the inherent self-centering tendency of this type of selector. The same effect could, of course, also be obtained by operating the selector poppets through suitably shaped cams.

With spring-returned pushbuttons or any other equivalent impulse system there is no direct indication from the pilots to show the position of the main selector. A possible improvement consists in allowing the pushbutton to return sufficiently far to re-establish the same connections as are obtained when it is fully returned, but to stay depressed by a sufficient amount to give an indication and to return fully only when the opposite pushbutton is actuated. Suitable mechanical interlocks can be devised easily to achieve this effect. This would give an indication of the selector setting last chosen, but is still no absolute guarantee that the selector position is as shown, e.g., if the pushbuttons have been last actuated while the pump was not running. Exactly the same considerations apply to electrically controlled systems of the impulse type.

Reverting to the general case, let us first examine the problem when there is one single selector in the system. The latter may be of the live type or, if not, the pilot valve may be arranged to close the unloading valve whenever it is moved, as described later. Hence, if the cylinder is on its stops or if the machine is on some stop external to the cylinder, pressure will be available with either system at least when the pilot valve is operated. The main selector will move until it is at least partially open in the desired sense. As soon as the selector operates, pressure will drop if the load on the cylinder is very low or negative. In this case the selector may not open fully, but it will at least be partially open in the desired direction (the less it opens the more pressure will be available to operate it, due to throttling of the pump flow) and, hence, the desired connection is bound to be established. The partial opening of the selector is no drawback, since full opening will be obtained again when the cylinder load rises.

Difficulties may arise, however, if it is necessary

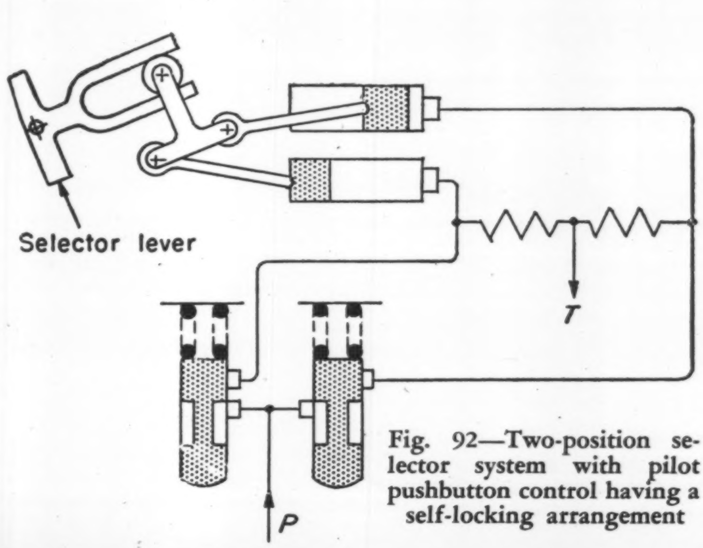
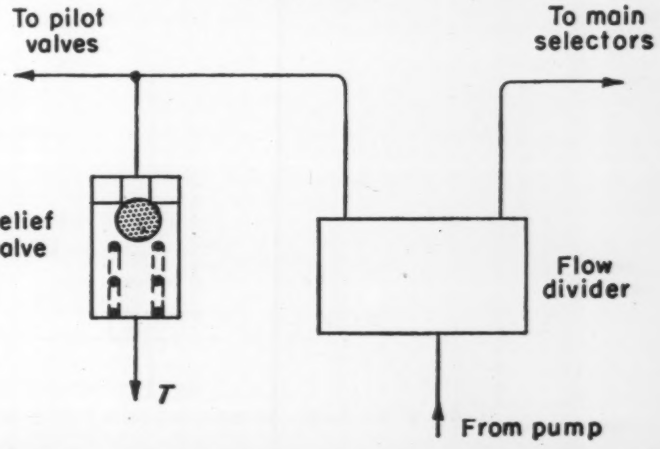


Fig. 92—Two-position selector system with pilot pushbutton control having a self-locking arrangement

Fig. 93—A flow divider providing unequal division provides a solution for pilot circuit supply problems



to reverse a cylinder while it is in motion against a very low or negative load before it comes to the end of its travel. In this case, and in the absence of suitable precautions, the pressure available may be insufficient to move the main selector, and operating the pilot valve will have no effect until the cylinder completes its travel or meets with increased resistance. The necessary precautions to avoid this will be considered in the following section.

Pressure Maintenance: The problem just mentioned also arises if there are a number of selectors, each controlled by its own pilot valve. Here again, difficulties may arise if any one selector is to be reversed while the cylinder it controls is moving against low load. The same difficulty arises also if there are say two cylinders, *A* and *B*, controlled by selectors, *a* and *b*, which in turn are controlled by pilot valves, α and β, and pilot valve β is operated to move cylinder *B* while *A* is in motion against a very low or negative load. In this case, selector *b* may not operate until cylinder *A* has completed its travel, or met with some resistance.

The general solution to this type of problem is to ensure the maintenance of a sufficient minimum pressure to the pilot valves irrespective of the pressure in the remainder of the delivery main. This could be done by a resistance or blow-off valve as shown in *Fig.* 30 of Part 1, but this circuit was intended to apply to pilot valves controlling unloading valves which may be made to operate under very low pressures, while selectors tend to have substantially higher operating loads. Thus, the lightest type —balanced slide selectors—may require as much as 10 per cent of the peak system pressure to ensure reliable operation.

Pressure may be reduced by operating the selectors with comparatively large pistons but this would make their construction cumbersome and increase the operating time, the figure of 10 per cent can be applied generally to pistons of diameter roughly equal to that of the spool. Maintenance of pressures of this order by a resistance or blow-off valve would involve inacceptable power dissipation in most cases and, thus, it is usual to employ a pressure-sequence valve. A pressure-sequence valve will maintain any required

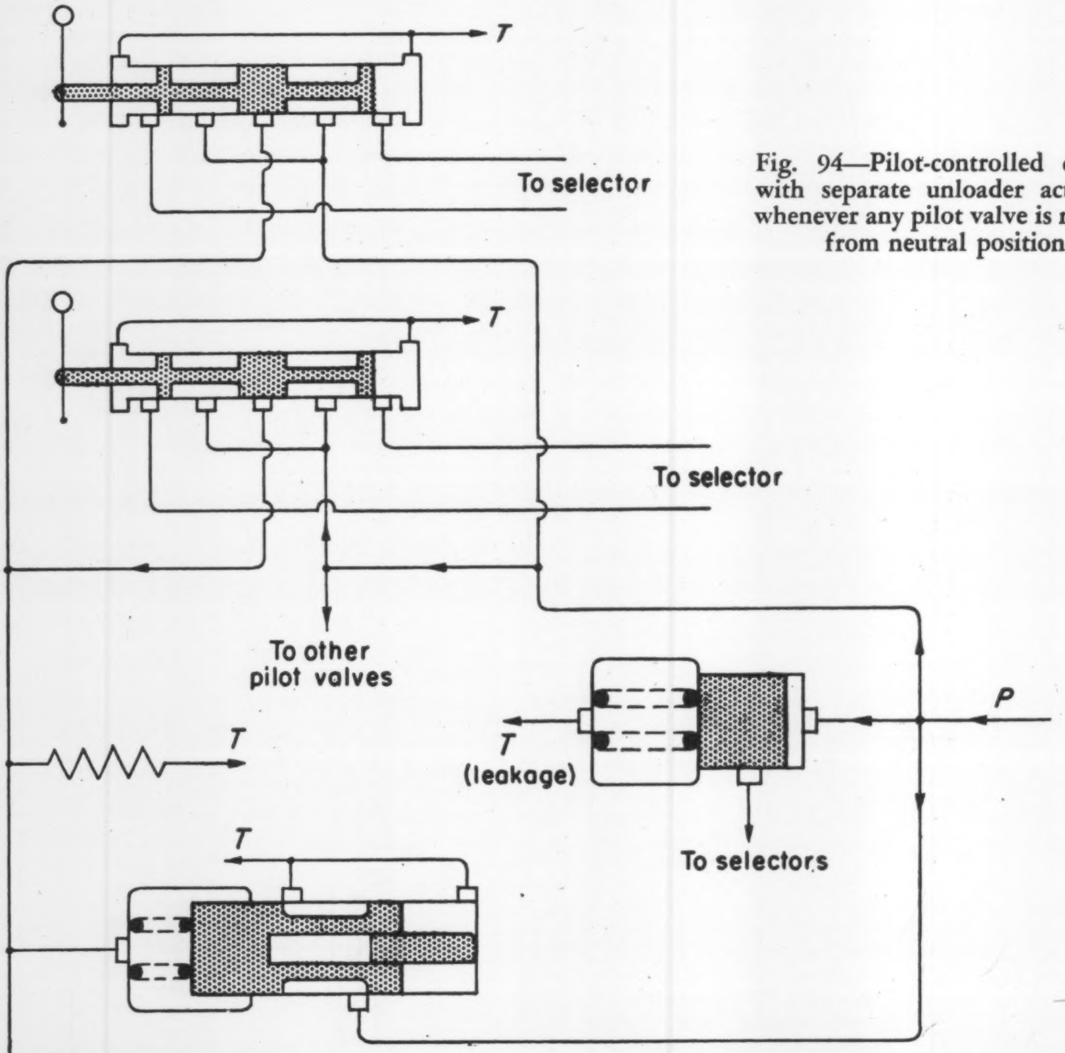


Fig. 94—Pilot-controlled circuit with separate unloader actuated whenever any pilot valve is moved from neutral position

pressure to the pilot valves without involving any power dissipation if the system pressure exceeds the valve setting, the valve then being fully open.

To recapitulate, the maintenance of a minimum pressure to the pilot circuit is necessary under one or both of the following conditions:

1. If a cylinder may have to reverse while moving against a very low or negative load.
2. If motion of one cylinder may have to be initiated while another is moving against very low or negative load.

A third condition will now be considered.

Pilot Control of Open-Center Selectors: For open-center systems it is necessary to be able to start a main selector moving while the pump is unloaded, and here again the problem arises of providing sufficient pressure to the pilot circuit.

In general, there appears to be no other solution than to maintain a sufficient residual pressure in the unloaded condition by a pressure-sequence valve or some equivalent means. Thus, appreciable load is maintained even in the nominally unloaded state and in perhaps the majority of cases such a load cannot be tolerated, particularly from the point of view of heat dissipation. For this reason pilot control is seldom applied to open-center systems. Other methods of unloading are more suitable for pilot-controlled systems. Some of these methods will be described later.

In the case of slide valves in particular, pilot-operated open-center selectors may of course still be an acceptable solution if partial unloading, say, to 10 or 15 per cent of the peak pump power, is sufficient. Another case should be mentioned; in certain systems having two pumps, one of which is of relatively low capacity, the smaller pump may be kept under load or only partially unloaded and may in addition to its other duties, supply pilot valves which control the output of the large pump (or of both) through open selectors. The larger pump can then be fully unloaded through the open-center valves.

Yet another solution would be to use a flow divider to supply the pilot circuit with a relatively small fraction of the pump output. Pressure can then be maintained in the pilot lines without entailing undue power consumption. A flow divider of the throttling type *Fig.* 75*a* (Part 1 of this series) would be useless for this purpose and a motor type flow divider, similar in principle to that of *Fig.* 75*b* but giving unequal division, would be necessary. The resulting circuit is shown in *Fig.* 93. The relief valve is set to whatever pressure is required for the pilot valves to be effective. The idling power consumption is equal to the product of the flow in the pilot circuit and the relief valve pressure. In elaborate installations it might not be out of the question to go one step further and have a separate pump for the pilot system.

Coupled Unloading Control Through Pilot Valves: The difficulties associated with pilot controlled open-center selectors are avoided by using an equivalent system in which the unloading function is vested in a single separate valve and the pilot valves are so arranged as to close the latter when any one of them is moved away from neutral, say, by applying pressure to the unloading valve control connection.

A circuit of this type is shown in *Fig.* 94. The unloading valve is of the type shown in *Fig.* 27*b* and maintains a very low residual pressure, just sufficient to effect its closure when a pilot valve is operated.

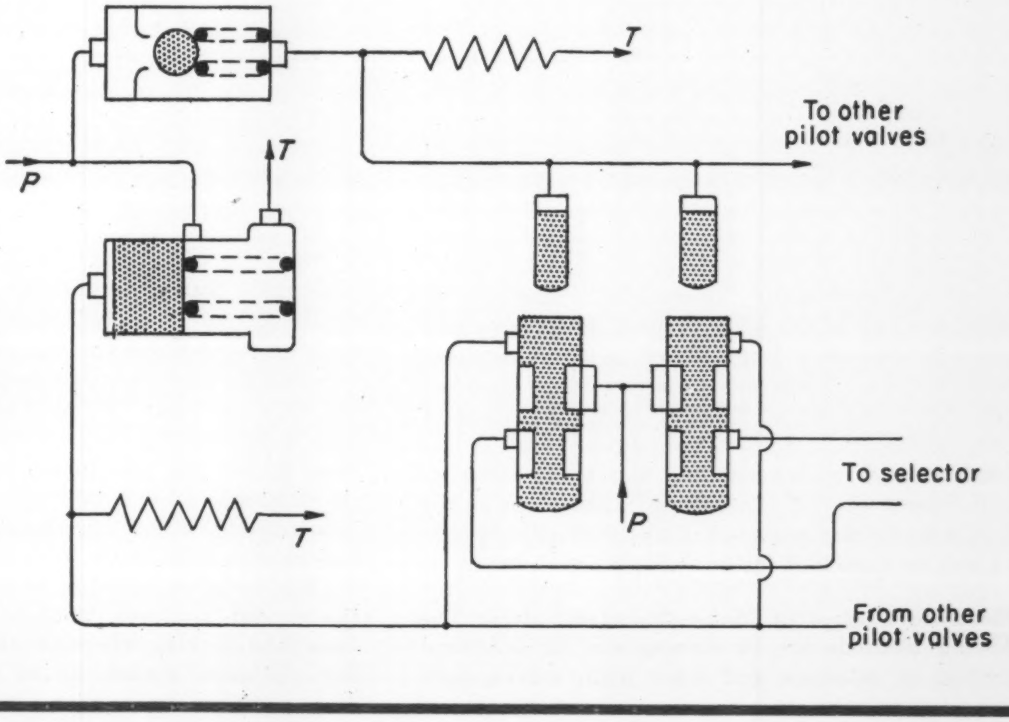


Fig. 95—Pushbutton-pilot controlled hydraulic system with positive piston return

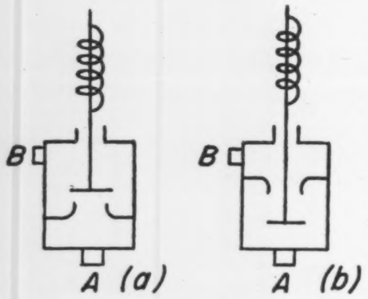


Fig. 96 — Solenoid-operated valves of two types: closed when de-energized, *a*, and open when de-energized, *b*

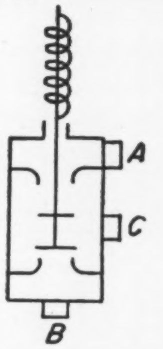


Fig. 97 — Common style of three-way solenoid - operated valve

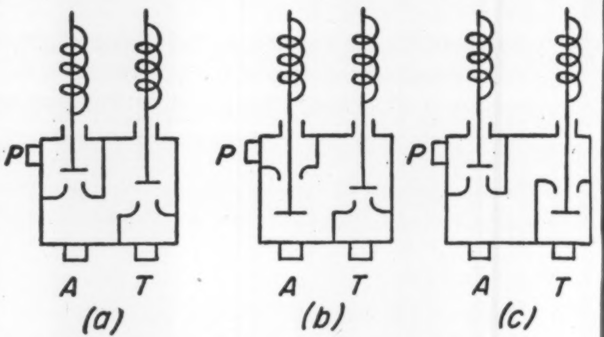


Fig. 98—Three-position, three-way selectors made up from combinations of two normally open and normally closed valves

After the unloading valve is closed, the pressure-sequence valve ensures that sufficient pressure is available to operate the selectors irrespective of circuit conditions; if the latter are always favorable the pressure-sequence valve may be dispensed with.

The foregoing circuit is equivalent to the open-center system of *Fig.* 40, no restriction being placed on the simultaneous operation of two or more cylinders. It is also equivalent in the sense that the pilot valve must be released or returned to neutral after completion of an operation to effect unloading.

The circuit cannot be kept unloaded as with open-center systems, during the return motion of a single-acting cylinder, due to the necessity of having pressure to operate the selector, unless the latter is of the two-position type (which is not possible in the case of double-acting cylinders) and spring biased towards return. In this case the corresponding pilot valve will also have only two positions.

It is quite easy to devise a system based on pairs of spring-returned pushbuttons exactly equivalent to that of *Fig.* 28, but with the pushbuttons controlling the selectors as well as the unloading valve. The selectors would be of the two-position stay-put type.

A somewhat different type of pushbutton system, used in conjunction with spring-centered selectors, is shown in *Fig.* 95. The pilot valves consist of pairs of spring-returned pushbuttons, but are locked in the depressed position until released by a small piston which comes into action when the relief valve operates, the system then being again unloaded. Locking could be very simply achieved for instance by causing the end of the slide to stick to a permanent magnet in the valve body, which is strong enough to hold it against the return spring until the resetting piston comes into action. This system is the equivalent of the automatic type of open-center system described in the previous article and lends itself to modifications wherein the release takes place at the end of a particular sequence. Equivalent electric systems will be described in the following section.

Electrical Control by Motor-Operated Valves: The following methods are in current use for electrical operation of selectors and other main valves, such as blocking valves:

1. Operation by motor.
2. Direct operation by electromagnets or solenoids.
3. Operation by solenoid-actuated pilot valves.

In the case of motor operation, reduction gear is invariably required. The usual method is to use a reversing motor operated by two pushbuttons which may be of the stay-put or spring-returned type. A relay is necessary in the latter case unless the button is held for the duration of the motion. If a relay is used, or if the control is by stay-put buttons or equivalent device, the motor must switch itself off after completion of its travel, this being done by limit switches. Motor overrun may be accommodated by allowing some overtravel, or by a slip coupling. Again, there may be a clutch which, when disengaged, acts as a brake and holds the valve in position—otherwise the valve should be of the stay-put type. A separate solenoid to operate the clutch may be avoided by making use of the type of motor which attracts the armature inward when switched on, the axial movement of the armature being used to engage the brake and disengage the clutch.

In one recent valve design the problem is solved by a screw jack in which the nut is allowed to run off the screw at the end of the travel. Where required, neutral can be reached by making use of a switch which cuts off the motor when the selector is at mid-travel; the control element is then a three-position switch, or triple pushbutton. Electric circuits for all these cases are easily devised from basic principles.

Solenoid Valve Actuation: Practically all valves require a considerably higher load at the start of their travel than for the remainder of the motion and this applies both to seating and port types. Perhaps the only exception is the case of seating valves of such small size that they cannot pass the full pump flow under the maximum system pressure. This characteristic blends well with that of ac solenoids, in which the larger air gap at the beginning of the motion is compensated by a reduced impedance, the winding being designed to be heavily overloaded until the air gap is closed. This, of course, has the drawback that sticking will cause the winding to burn out. For the same reason, an ac solenoid can do much more work per stroke than a dc type, for a given size.

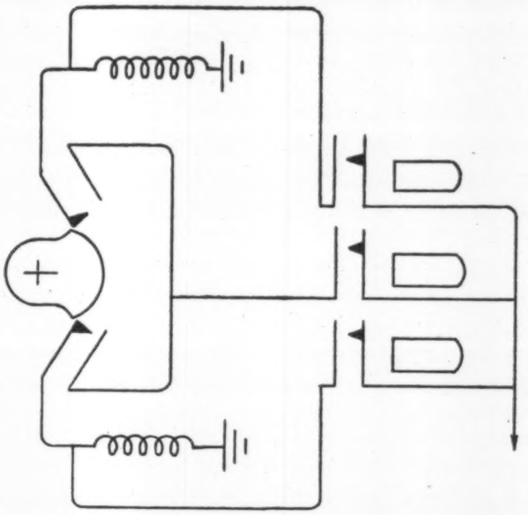


Fig. 99—Electrical circuit for an impulse type solenoid-operated selector with a special neutral arrangement

According to Ernst (Ref. 2, Part 1) the vibration in ac solenoids has the effect of eliminating the initial friction in slide valves. An ac solenoid need, therefore, only be strong enough to overcome the bias spring, and not the sum of spring and friction loads. The author has no experience to confirm or refute this statement but regards it with some reserve. If it were true, then the solenoids required to operate slide valves without spring bias (such as two-position valves with a solenoid for each direction of movement) could be quite small, which is not borne out by commercially available equipment.

The effectiveness of solenoids for valve operation may be increased by allowing a certain amount of impact, i.e., giving the armature some idle travel before it begins to move the valve. This feature is rarely seen on ac operated valves, but has been used with dc, in which case the best results seem to be obtained by opposing the solenoid pull right from the start of the motion by a spring of suitable strength, probably because this allows current to build up to some extent before motion begins.

In the case of dc solenoids a very neat and efficient construction is obtained by combining the magnetic circuit with the valve body, which can be done in such a manner as to avoid moving seals altogether. With ac solenoids this seems hardly feasible, as the core and armature must be laminated (it is of course still possible to avoid moving seals by having the solenoid "drowned" inside the valve body, but this construction does not appear ever to have been attempted, and is almost certainly not worthwhile.)

Attempts have been made to increase the power of dc solenoids by having two windings initially in parallel, which automatically switch over to series when the solenoid has closed. Direct-current solenoids lend themselves better to the operation of seating than of slide valves, as the former require lower strokes.

Solenoid-Operated Seating Valves: In the case of two-way seating valves, two basic types are possible: (1) closed when de-energized, *Fig.* 96*a*, and (2) open when de-energized. *Fig.* 96*b*. The convention in these two and other symbols is that the valve stem is attracted into the coil when energized. In practice, to keep the seat diameter as low as possible in the case of *Fig.* 96*b*, the solenoid is best placed below the valve, avoiding the stem through the orifice. In the case of *Fig.* 96*a*, *B* is usually the pressure connection, but

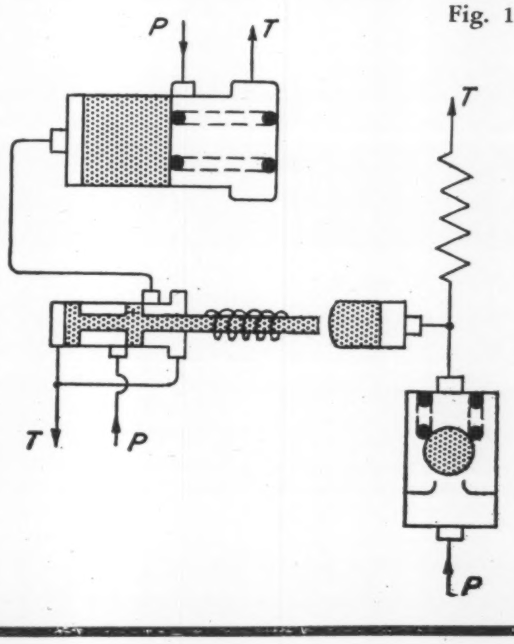


Fig. 100 — Left — Solenoid-operated unloading valve with hydraulic opening means

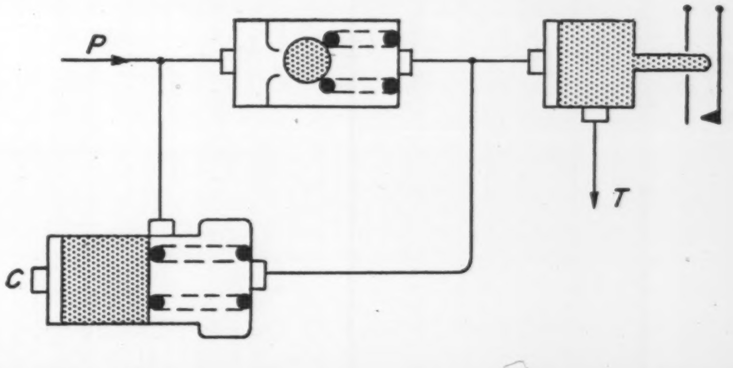


Fig. 101—Below—System in which final unloading is effected by connecting both relief and unloader valve outlets to the control piston

the reverse is possible if a sufficiently strong spring is provided. This in theory would not increase the size of solenoid required, but appears to have no advantage. In the case of the normally open valve of *Fig.* 96*b*, if *B* is pressure, no spring is necessary, but if *A* is pressure a powerful spring must be provided to open the valve. The size of solenoid would again remain substantially the same in the two cases.

A common type of three-way valve is shown in *Fig.* 97. In the case of dc operation, it is convenient to have the winding between the two valves to avoid a stem through the upper orifice (orifices as small as 0.015-inch have been used for pilot valves). In the most common application *C* is the connection to work (usually the operating piston of a larger valve), *A* being pressure and *B* tank, or vice versa, according to which combination of connections is required when de-energized. If *B* is pressure, a powerful return spring must be provided.

Three-position three-way selectors may be made up from various combinations of two normally closed and normally open valves. Thus the selector of *Fig.* 98*a* gives neutral when de-energized. The selectors of *Figs.* 98*b* and *c* give *A* to pressure and *A* to tank respectively when de-energized. Selectors of the last two types have been used for instance for controlling cylinders operating aero engine radiator shutters under control of a thermostat, the arrangement being such that the shutters open if electric power to the solenoid valves fails.

Methods of Solenoid Operation: For selectors and other main valves, operation may be direct by a solenoid or solenoids of suitable strength, or by solenoid-operated pilot valves. Direct operation has the advantages of high speed, and of not requiring maintained pressure as pilot valves often do. If the main valve has to be big enough to handle even quite moderate powers the solenoid is apt to be very cumbersome, and to require heavy currents and, hence, also relatively heavy switchgear and wiring. For these reasons pilot operation is quite frequently adopted.

If the valve—usually a selector— is spring-centered or biased in one direction, the operating solenoid must be kept energized as long as the required position of the valve is to be maintained. Two-position valves—particularly slide valves—may be made of the stay-put type, in which case it is sufficient to give the solenoid an impulse, e.g., by controlling it with a spring-returned pushbutton. Impulse operation is also applicable to pilot-operated selectors, in which case three positions are still obtainable (see below). Its advantages are that the solenoids can be made smaller since they need be rated for a few seconds only, if that, and that current is economized (this is usually an unimportant consideration, except perhaps in aircraft and vehicle applications). With spring-biased selectors or other valves a single solenoid is sufficient, while with spring centering or stay-put action two solenoids are necessary.

In *Fig.* 99 is shown the electric circuit for an impulse type solenoid pilot-operated selector, similar to the hand pilot operated type of *Fig.* 92, but with a special arrangement for obtaining a neutral position. When the central pushbutton is depressed, the correct solenoid of the pair is automatically selected through the contacts operated by the cam on the selector lever. It is switched off again as the contacts open when the selector reaches its central position. Similar arrangements cannot be used with direct (as opposed to pilot) solenoid operation, because motion is too rapid. Pilot solenoid valves are frequently mounted on the main valve which they operate.

Electrical Control of Unloading: In the case of live systems, there is no call for interconnection between selector control and control of the unloading means. Some systems use an electrically controlled cut-out valve, but this is usually independent of the rest of the electrical control system. The case for electrical control of cut-out valves seems very weak. A live system may also be unloaded by switching off the motor, but here again the control means for this would be independent. In some nonlive systems unloading is controlled according to the cycle of operations, and here too the control may be electrical.

The only systems to be considered for the present are the equivalent of those in which the operation

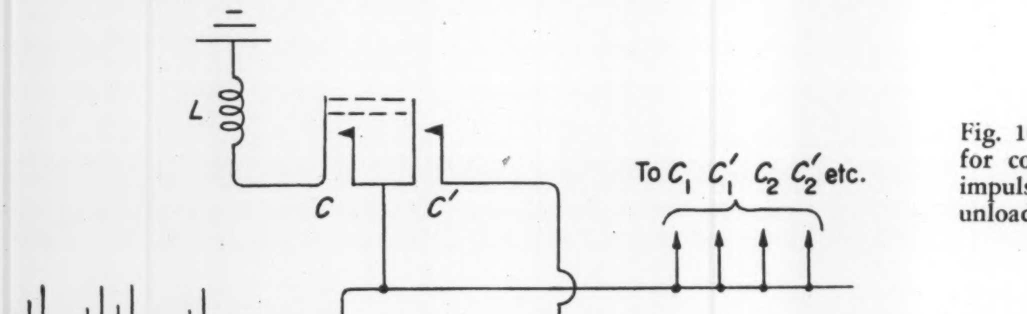


Fig. 102 — Circuit suitable for control of selectors by impulse solenoids, *L*, and unloading valve, *U*, with pushbuttons

of putting a pump back on load is coupled with the operation of actuating a selector. In the case of electrical control this coupling is most easily obtained through the electric circuit.

Unloading may be effected by switching off the motor, or by an electrically controlled unloading valve. The circuits shown apply to solenoid-operated valves, but equivalent circuits for motor-operated valves can be easily devised, and will differ but little from those illustrated here.

If the unloading valve is solenoid-operated, the action may—as in the case of selectors—either be of the holding or impulse type. In the latter case, special means must be provided to open the valve. The latter may have a second solenoid which is automatically given an impulse at the required moment, but preferably it may be arranged to open automatically by hydraulic means, as shown for instance in *Fig.* 100. The controlling element is a solenoid pilot valve which, when energized, applies pressure to the control connection of the unloading valve, closing the latter. The pilot valve has stay-put action and therefore stays closed although the solenoid is released. The pilot valve is reset by outlet flow from the relief valve causing the unloading valve to open.

Description of the simplest case, equivalent to plain open-center systems, in which a pushbutton must be held depressed for the duration of an operation may be omitted and unloading at the end of an operation assumed to be effected automatically. In this case, if the unloading valve is of the hold-on solenoid type, or if unloading is obtained by switching off the motor, means must be provided of automatically breaking the necessary portion of the electric circuit. This means may take the form of a pressure switch or, perhaps preferably, a switch operated by outlet flow from the relief valve.

The piston may be connected in the relief valve outlet line as in *Fig.* 16, Part 1, in which case contact is broken when maximum pressure is reached but made again as soon as the system is unloaded. Also, it may be connected as in Fig. 101, where it is operated by the outlet flow from both the relief valve and the unloading valve and contact is re-established only when the unloading valve is closed and a selector is operated (in this case a combined relief-unloading valve may be used).

The system of *Fig.* 16, or a plain pressure switch, may be used to break the self-holding contact of a relay. The system of *Fig.* 101 may be used to keep closed an unloading valve operated by a solenoid of the hold-on type. *Fig.* 102 shows a circuit suitable for impulse operated selectors (typical solenoid winding *L*) and unloading valve (solenoid winding *U*), the latter being of the type of *Fig.* 100 or equivalent. Control is by spring returned pushbuttons, each of which operates a pair of contacts *C, C'*.

With hold-on solenoids, a relay may be used. The same action may, however, be obtained in a simpler manner by using pairs of pushbuttons—one pair for every selector— of the partially returning type, a button springing back about half-way and fully back only when the opposite button is pressed. Each button can then be made to operate both holding and nonholding contacts, the latter being broken when the button returns partially, and the former only when it returns fully. A circuit based on this kind of action is shown in *Fig.* 103 where unloading is controlled by a flow switch of the type of *Fig.* 101. Both selector and unloading valve are of the hold-on solenoid type, the winding of the former being shown (typically) at *L*, and of the latter at *U*. Each pushbutton operates three pairs of contacts, *C, C'* and *C''*, the first two being of the holding and the last of the nonholding type. The mode of action is self-explanatory.

Part 4 in this series which covers automatic-sequence systems and their design will appear in the July issue of MACHINE DESIGN.

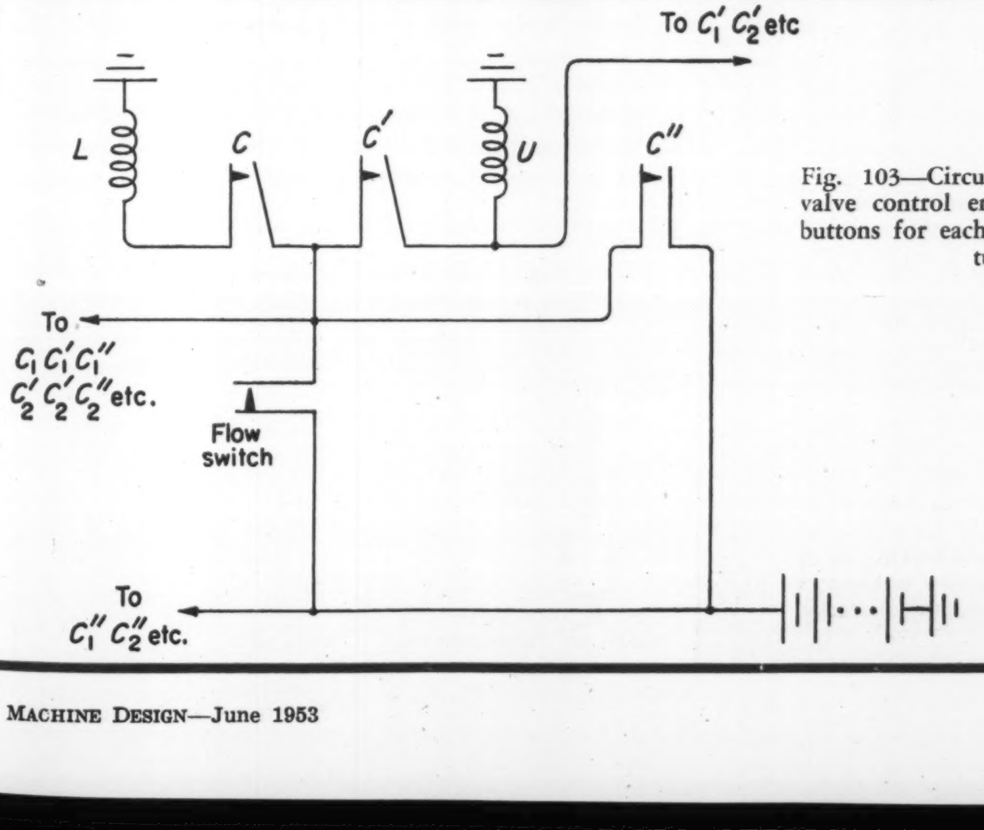


Fig. 103—Circuit for hold-on solenoid valve control employing pairs of pushbuttons for each selector with partial-return action

Flow Control System

. . . balances pumping capacity and flow rate

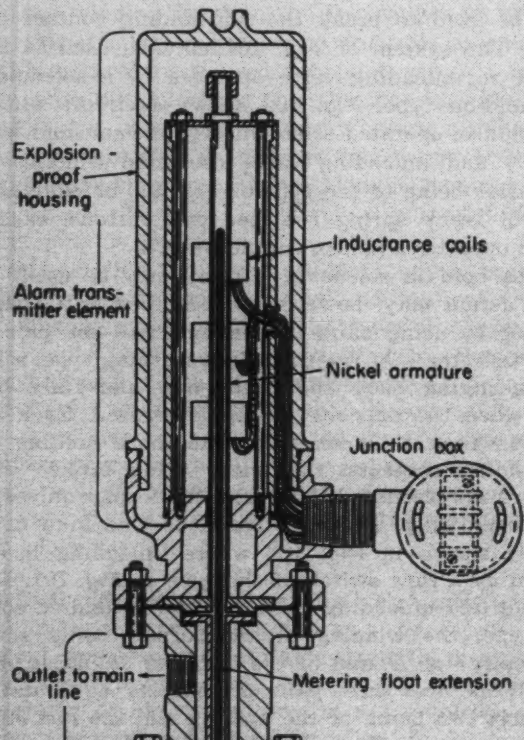

Explosion-proof housing
Alarm transmitter element
Inductance coils
Nickel armature
Junction box
Outlet to main line
Metering float extension
Metering float
Metering element
Pressure seal enclosure
Metering tube
Inlet from main line
Range Orifice

Fig. 1—Nickel alloy tube moving up or down through coils of the inductance transmitter controls pump operation

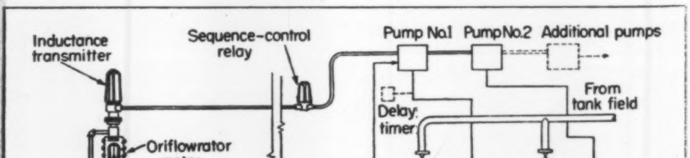
FAST response to demand variation in a fluid flow system can be provided by a combination of flowmeter and transmitter using variable inductance principles. Heart of the newly developed system is a variable inductance transmitter which automatically maintains a continuous balance between pumping capacity and flow rate.

As a float in the flowmeter, *Fig.* 1, rises in response to changes in flow rate, a nickel-alloy tube mounted on the float moves up through the centers of the coils in the inductance transmitter directly above the meter. Inductance of the transmitter thus changes sharply. This change in inductance or impedance controls the pumping system.

Operation of the system, *Fig.* 2, developed by Fischer and Porter Co. is sequential. As soon as a discharge nozzle is opened, a pressure switch located in the discharge line senses the drop in pressure and turns on pump No. 1. Liquid flow through the discharge line is measured by the flowmeter located in a by-pass of the main discharge line, and variations in flow rate are transmitted to a thyratron circuit to place the required number of pumps in operation. Steady line flow at low or erratic flow rates, such as those encountered when tanks are being topped-off, is maintained by a time delay switch in series with pump No. 1 to complete the topping-off.

Coils of the transmitter may be reset in the field to provide any desired flow rate. Any pressure drop in the system due to slight leakage during long idle periods will be sensed by the pressure switch and No. 1 pump placed in operation until normal pressure is restored This feature maintains constant pressure in the system and assures normal delivery as soon as a discharge nozzle is opened.

Fig. 2—Flowmeter is connected into bypass from main discharge line


Inductance transmitter
Sequence-control relay
Pump No.1
Pump No.2
Additional pumps
From tank field
Delay timer
Oriflowrator meter
Pump No. 1
Pump No. 2
To loading rack
Standard orifice flanges
Pressure switch

GRAPHICAL LINKAGE ANALYSIS

A direct method for the design of four-bar linkages to perform a given function

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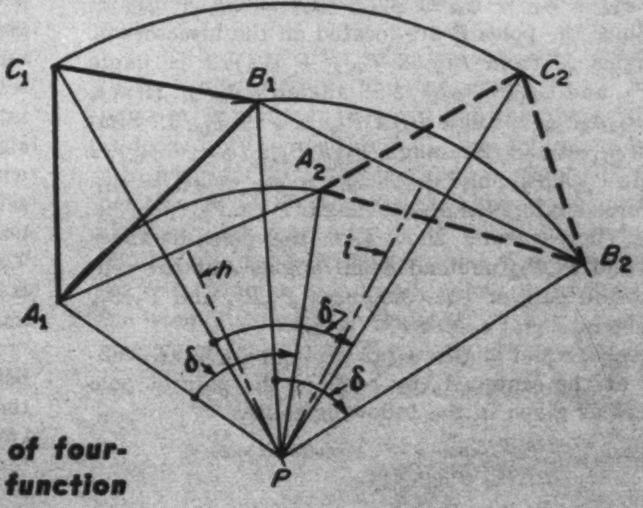


Fig. 1 — Movement of a plane represented by rotation about a virtual center

DESIGN of four-bar linkages for specific outputs has been approached by different methods in recent years. The aim of each, of course, is to circumvent trial and error and to develop rational procedures for the "synthesizing" of mechanisms possessing certain required characteristics. This article presents another technique for the solution of four-bar linkage problems. It is based upon the use of a curve as a geometric focus containing all solutions to a given problem.

The geometric locus so useful in the determination of linkages such as harmonic transformers or those for producing straight-line motion is known as the curve of Burmester's centers. This concept can be readily developed through several evolutionary stages, and its application to specific designs demonstrated.

Curve of Burmester's Centers: In *Fig.* 1, a plane coinciding with the plane of the paper and denoted by A_1B_1 moves to any position A_2B_2. This movement can be performed by rotation about point P, which is the point of intersection of the perpendicular bisectors h and i of the distances A_1A_2 and B_1B_2. Since the triangles A_1B_1P and A_2B_2P are congruent, the angle of rotation A_1PA_2 = angle $B_1PB_2 = \delta$. Any point C_1 in the plane defined by A_1B_1 will move to the position C_2 due to the rotation of the arm PC_1 through the angle δ.

The actual motion of the plane from position A_1B_1 to A_2B_2 may not necessarily be a rotation about the center P. However, if only certain positions of the plane are under consideration, this actual motion is not significant and can be replaced by a rotation about P, the virtual center, or pole, of rotation.

If three positions, A_1B_1, A_2B_2 and A_3B_3 of a plane are given, as in *Fig.* 2, the bisectors h_{12} and i_{12} intersect at P_{12} and angle δ_{12} is the angle of rotation from position A_1B_1 to A_2B_2. Similarly, h_{23}, i_{23}, P_{23} and δ_{23} define the rotation of the plane from A_2B_2 to A_3B_3 and h_{13}, i_{13}, P_{13} and δ_{13} rotation from A_1B_1 to A_3B_3. Note that the perpendicular bisectors also bisect the respective angles of rotation.

For four positions of a plane there are six poles of rotation: P_{12}, P_{13}, P_{14}, P_{23}, P_{24} and P_{34}. In *Fig.* 3 the plane is shown in four positions, A_1B_1 to A_4B_4, with the six perpendicular bisectors, h_{12} to h_{34}, of distances A_1A_2 to A_3A_4 and the six perpendicular bisectors, i_{12} to i_{34} of distances B_1B_2 to B_3B_4 (bisectors with the same suffixes intersect at the poles P similarly identified). The positions A_1 to A_4 have been chosen on the circumference of a circle with center A_0. Therefore, the bisectors h must pass through A_0. The radius A_0A_1 rotates from A_1 to A_2 through the angle ϕ_{12}, from A_2 to A_3 through the angle ϕ_{23} and so on. Thus, $\phi_{14} = \phi_{12} + \phi_{23} + \phi_{34}$ or $\phi_{14} - \phi_{34} = \phi_{12} + \phi_{23} = \phi_{13}$. Since the poles P are located on the bisectors of the angles ϕ, from *Fig.* 3 $(\phi_{12} + \phi_{23})/2$ = angle $P_{12}A_0P_{23}$ and $(\phi_{14} - \phi_{34})/2$ = angle $P_{14}A_0P_{34}$. Hence, angle $P_{12}A_0P_{23}$ = angle $P_{14}A_0P_{34} = \epsilon = \phi_{13}/2$. Similarly, $(\phi_{14} - \phi_{12})/2$ = angle $P_{12}A_0P_{14}$; $(\phi_{23} + \phi_{34})/2$ = angle $P_{23}A_0P_{34}$; and $\phi_{14} - \phi_{12} = \phi_{23} + \phi_{34} = \phi_{24}$. Therefore, angle $P_{12}A_0P_{14}$ = angle $P_{23}A_0P_{34} = \epsilon' = \phi_{24}/2$. These results show that the pole distances $P_{12}P_{23}$ and $P_{14}P_{34}$ subtend equal angles ϵ at the center A_0; the pair of pole distances $P_{12}P_{14}$ and $P_{23}P_{34}$ also subtend equal angles ϵ'.

Likewise, equal angles $\phi_{12}/2$ through $\phi_{34}/2$ are subtended at the center A_0 by each of the pair of pole distances as given in the following table:

Pole Distances	Subtended Angle
$P_{14}P_{24}$, $P_{13}P_{23}$	$\phi_{12}/2$
$P_{12}P_{23}$, $P_{14}P_{34}$	$\phi_{13}/2$
$P_{12}P_{24}$, $P_{13}P_{34}$	$\phi_{14}/2$
$P_{12}P_{13}$, $P_{24}P_{34}$	$\phi_{23}/2$
$P_{12}P_{14}$, $P_{23}P_{34}$	$\phi_{24}/2$
$P_{14}P_{13}$, $P_{23}P_{24}$	$\phi_{34}/2$

If, for instance, $\phi_{13}/2$ is given, the corresponding pole distances $P_{14}P_{34}$ and $P_{12}P_{23}$ can be used to locate A_0.

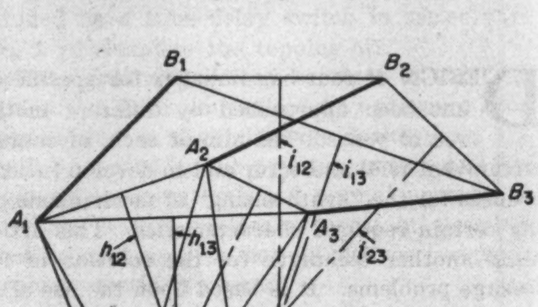
In general, if the angles ϕ are not given, a circle on which a point A of a moving plane has four positions, A_1, A_2, A_3 and A_4, can have such a center A_0 only when the pairs of pole distances subtend equal, or supplementary, angles.

The center A_0 of a circle on which a point A of a plane lies in four positions is called Burmester's center. Point A may travel on the circumference of the circle to reach the four positions A_1, A_2, A_3 and A_4 or may follow a path which has only these four points in common with the circle. The center A_0 can, therefore, be found by constructing triangles having the same vertex A_0 and the known pole distances as bases, with the pole distances subtending equal angles at the vertex. For instance, in *Fig.* 3 the pole distances $P_{12}P_{23}$ and $P_{14}P_{34}$ subtend the equal angles ϵ at the vertex A_0. By varying ϵ, with the pole distances remaining the same, the locus of the vertex A_0 can be found. This locus is called the curve of Burmester's centers, μ, and goes through six points π at which the lines of the pairs of pole distances intersect. For example, the lines of $P_{12}P_{23}$ and $P_{14}P_{34}$ intersect at π_{13}. At this point, the pole distances subtend equal angles, which by the construction, are both zero. Thus, π_{13} is a point of the curve. In addition, the curve also passes through the six poles P. Thus, twelve points are known before the actual design of such a curve is started.

Straight-Line Motion: The application of the curve of Burmester's centers to design a four-bar linkage for producing straight-line motion is illustrated in *Fig.* 4. Four positions, C_1, C_2, C_3 and C_4, of a point C on the connecting rod BC are assumed on a straight line. Also, the base joint B_0 and the connecting joint B in the position B_1 are assumed. Thus, from the length $BC = B_1C_1 = B_2C_2 = B_3C_3 = B_4C_4$, the positions B_2, B_3 and B_4 on the arc about B_0 and through B_1 may be determined. By construction of the perpendicular bisectors, as previously explained, the six poles P and six points of intersection π could be determined. However, this process may be simplified by selecting a pair of pole distances from the previous table and drawing only those bisectors needed to design the curve. This method has been used in *Fig. 4a* where the pole distances, $P_{12}P_{24}$ and $P_{13}P_{34}$, have been selected. Accordingly, the bisectors m_{12} of the distance C_1C_2 and i_{12} of the distance B_1B_2 are drawn. These bisectors intersect at the pole P_{12}; the bisectors m_{24} and i_{24} at P_{24}; the bisectors m_{13} and i_{13} at P_{13}; and m_{34} and i_{34} at P_{34}.

Since the curve is the locus of points at which the pole distances $P_{12}P_{24}$ and $P_{13}P_{34}$ subtend equal angles, these points may be located at the intersections of two circles in which the chords $P_{12}P_{24}$ and $P_{13}P_{34}$ subtend the same angles ϵ. To find such a pair of circles, the lengths $P_{12}P_{24}/2$ and $P_{13}P_{34}/2$ are drawn from a point O as shown in *Fig. 4b*. At the ends of these lengths perpendiculars are erected and a line drawn from O at an arbitrary angle ϵ to obtain the lengths x and y. These lengths are transferred to the corresponding bisectors m_1 and m_2 of the chords in *Fig. 4a*,

Fig. 2—Location of virtual centers of rotation for three given plane positions



thus giving the centers M_x' and M_y' as well as M_x'' and M_y'' of circles k_x', k_y', k_x'' and k_y'' respectively. The points of intersection of circle k_x' with k_y' and k_x'' with k_y'' are points S of the curve μ of Burmester's centers. By varying the angle ϵ in *Fig.* 4*b* and repeating the described procedure, one may find as many points as desired.

The circle over chord $P_{12}P_{24}$, which goes through P_{13}, intersects the circle over $P_{13}P_{34}$ at P_{13}. Hence, this pole, and for the same reason all the six poles of rotation, are points of the curve.

If the angle $\phi_{14} = A_1A_0A_4$ is given, $\epsilon = \phi_{14}/2$ and according to the table, the pair $P_{12}P_{24}$ and $P_{13}P_{34}$ must be used, verifying the selection made in *Fig.* 4*a*. The curve μ need not be drawn but by drawing this angle ϵ in *Fig.* 4*b*, two pairs of circles k_x', k_y' and k_x'', k_y'', which intersect in four points S, may be found. Any of these points S may be chosen as locus for the base joint A_0. In any case, the crank A_0A rotates through the given angle ϕ_{14} while point C moves from position C_1 through C_2 and C_3 to position C_4.

If the angle ϕ_{14} is not given, the curve μ is drawn and any point of this curve is then selected as the point A_0.

In both cases, after selecting A_0, point A_1 will have to be determined to find the crank A_0A. For this purpose, if point A_0 is marked on the plane BC, which is defined in the position B_2C_2, and this plane is moved into position B_1C_1, the marked point A_0 will move to position A_{02}. Since the yet unknown point A_2 coincides by this movement with the unknown point A_1 and because the lengths A_0A_2 and A_0A_1 are equal, having the radius of the crank, points A_0 and A_{02} are at the same distance from point A_1. Therefore, the perpendicular bisector of A_0A_{02} is a geometrical locus for

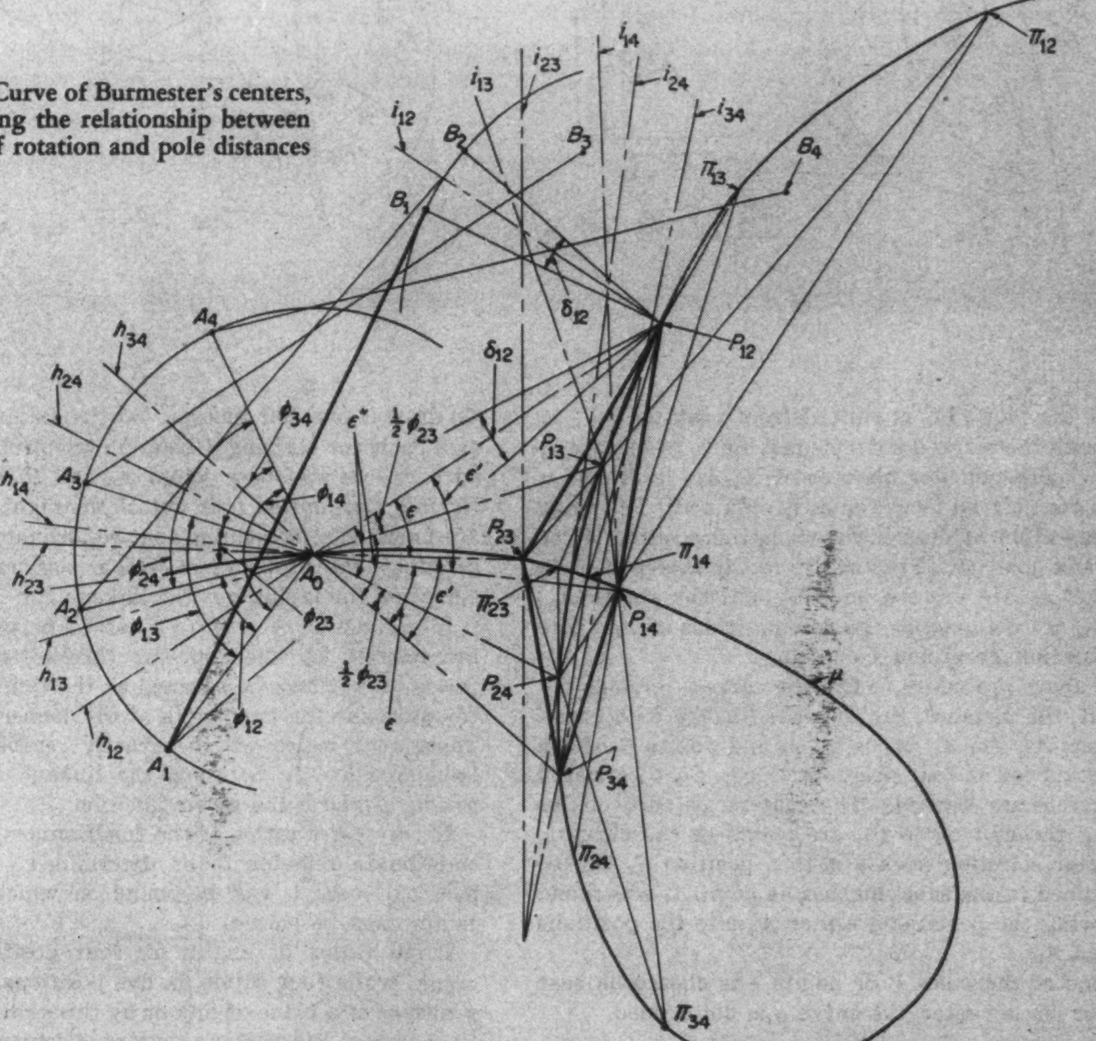
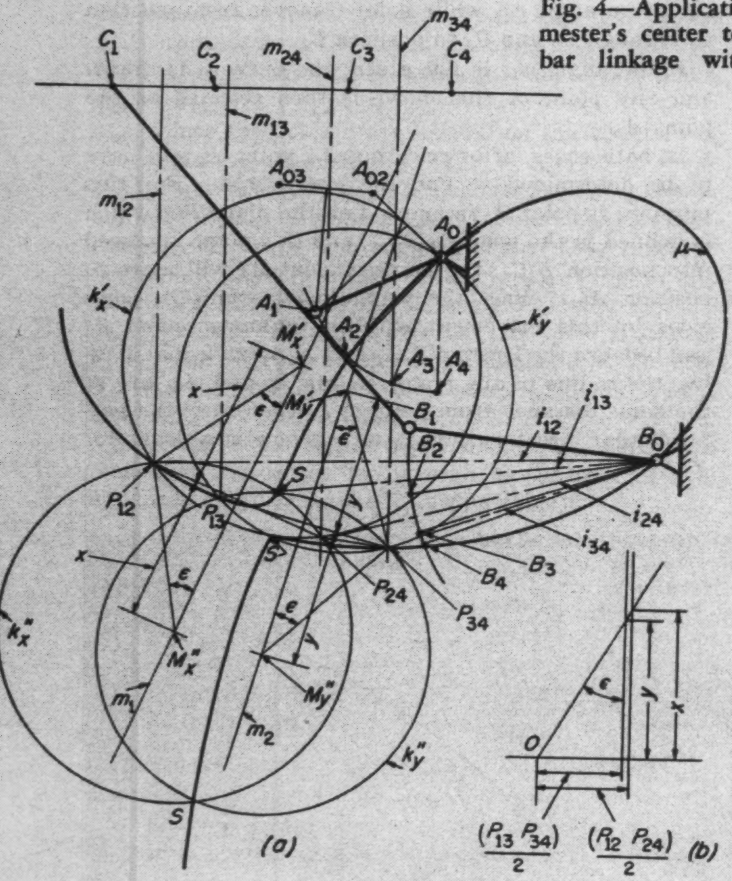
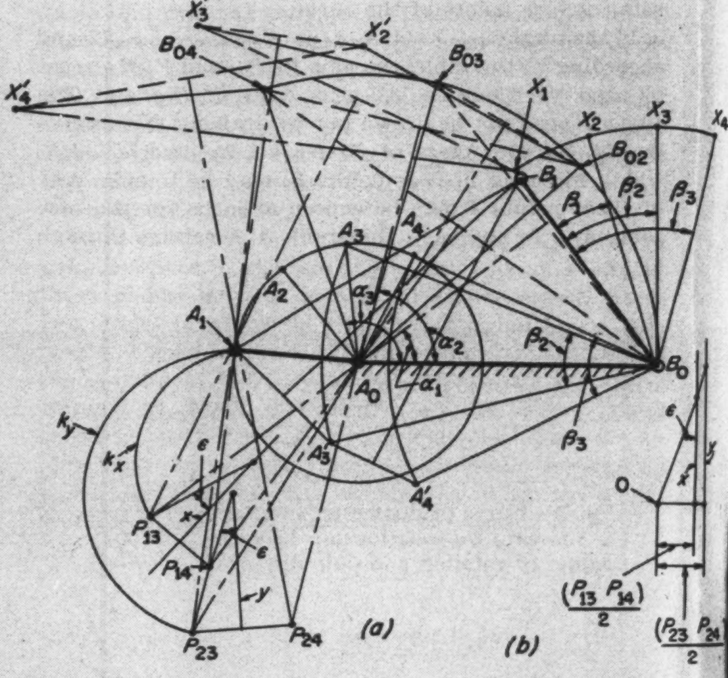

i_{12}
i_{13}
i_{23}
i_{14}
i_{24}
i_{34}
π_{12}
B_2
B_3
B_4
π_{13}
B_1
δ_{12}
δ_{12}
P_{12}
A_4
h_{34}
h_{24}
ϕ_{34}
ϵ^*
$\frac{1}{2}\phi_{23}$
P_{13}
ϵ'
A_3
h_{14}
ϕ_{14}
ϵ
P_{23}
π_{14}
h_{23}
ϕ_{24}
A_0
ϵ'
π_{23}
P_{14}
A_2
ϕ_{13}
ϕ_{23}
$\frac{1}{2}\phi_{23}$
P_{24}
μ
h_{13}
ϕ_{12}
ϵ
h_{12}
A_1
P_{34}
π_{24}
π_{34}

Fig. 3—Curve of Burmester's centers, μ, showing the relationship between angles of rotation and pole distances



C_1
C_2
m_{24}
C_3
m_{34}
C_4
m_{13}
A_{03}
A_{02}
m_{12}
A_0
μ
k'_x
A_1
M'_x
A_2
k'_y
A_3
A_4
x
ϵ
M'_y
B_1
i_{13}
i_{12}
B_2
B_0
S
P_{12}
P_{13}
i_{24}
i_{34}
B_3
B_4
P_{24}
P_{34}
k''_x
M''_x
M''_y
m_1
m_2
k''_y
y
O
$\frac{(P_{13}\ P_{34})}{2}$
$\frac{(P_{12}\ P_{24})}{2}$
(a)
(b)

Fig. 4—Application of the curve of Burmester's center to the design of a four-bar linkage with straight-line motion



X'_3
X'_2
B_{04}
B_{03}
X'_4
X_1
X_2
X_3
X_4
B_{02}
B_1
β_1
β_2
β_3
A_3
A_4
A_2
α_3
α_2
A_1
α_1
A_0
B_0
β_2
β_3
k_y
k_x
A'_3
A'_4
ϵ
x
y
P_{13}
P_{14}
P_{23}
P_{24}
O
$\frac{(P_{13}\ P_{14})}{2}$
$\frac{(P_{23}\ P_{24})}{2}$
(a)
(b)

Fig. 5—Design of a four-bar linkage for three given ratios of crank and lever angles, α/β

A_1. If the plane BC is shifted from position B_3C_3 to B_1C_1, with the marked point A_0 moving to position A_{03}, and the perpendicular bisector of $A_{03}A_{02}$ is drawn, a second geometrical locus for A_1 is obtained. The point of intersection of both bisectors is the position A_1 of the crank joint A. Practically, the triangles $B_2C_2A_0$ and $B_3C_3A_0$ are erected on B_1C_1 and the points A_{02} and A_{03} are obtained as the new positions of A_0. The four-bar linkage is now complete.

The above procedure to find the curve μ remains the same if, for instance, the four-bar linkage with crank positions A_1, A_2, A_3, A_4 is given and points C of the connecting rod in four positions C_1, C_2, C_3, C_4 situated on a circle are wanted. The centers, of such circles passing through C_1 to C_4, are points of the curve μ, and after selecting such a center, position C_1 can be determined in the same manner as point A_1 was found by moving the pertaining center A_0 into the positions A_{02} and A_{03}.

If one of the poles P or points π is chosen as base joint or circle center, the curve μ is not needed.

Performance of a Function: A four-bar linkage having four joints is known by dimensions and positions, when two co-ordinates of each joint are known. Thus a four-bar linkage is determined by eight co-ordinates. To draw a four-bar linkage, two joints must be known as a basis for starting. Thus for the problem presented here, the two base joints A_0 and B_0 are assumed. By this assumption four out of the eight co-ordinates are fixed. The remaining four co-ordinates may all be given by the problem, in which case no further assumption for laying out the linkage can be made.

If a function $\beta = f(\alpha)$ has to be performed approximately by the four-bar linkage, four limiting ratios of α/β may be selected as the four co-ordinates to determine the two joints of the connecting rod AB. These four ratios will be exactly reproduced by the linkage while, in between, the linkage will approximately perform the given function.

If only three ratios of the function are selected, one co-ordinate remains to be determined. Then a geometrical locus μ will be found on which one of the joints must be placed.

Three ratios of angles fix four positions of each crank, while four ratios fix five positions. From four positions of a plane or link or by three ratios of angles, the curve of Burmester's centers is determined; for instance, by α_1/β_1, α_2/β_2 and α_3/β_3. If a fourth ratio α_4/β_4 is given, a second curve of Burmester's centers may be drawn, for instance, for the ratios α_1/β_1, α_2/β_2 and α_4/β_4. The points of intersections of the two curves indicate where joints A or B must be located to get a four-bar linkage for four ratios of angles or five values of the function.

In *Fig.* 5*a* the base joints A_0B_0 are assumed, and the values of the angles α_1, α_2, α_3, β_1, β_2 and β_3 are given. In the completed linkage α_1, α_2, and α_3 are angles corresponding to positions A_2, A_3, and A_4 of crank plane A_0A and β_1, β_2 and β_3 are the angles corresponding to positions X_2, X_3 and X_4 of crank plane B_0X from their initial positions. If, for instance, X_1, X_2, X_3 and X_4 are the positions of a joint X, when the crank A_0A has the positions A_1, A_2, A_3 and A_4, then AX will be the connecting rod. The triangles $A_0B_0X_2$, $A_0B_0X_3$ and $A_0B_0X_4$ may be rotated about A_0 through the angles $-\alpha_1$, $-\alpha_2$ and $-\alpha_3$ to bring X_2, X_3, and X_4 to the positions X_2', X_3' and X_4', while by these rotations, the points A_2, A_3 and A_4 are made to coincide with point A_1. If XA were the real connecting rod, the points X_1, X_2', X_3', X_4' would be on a circle with A_1 as the center. This means A_1 is a point of the curve of Burmester's centers which has to be determined for the positions of members A_0B_0 and B_0B relative to member A_0A. For this purpose A_0A is considered as a fixed member and A_0B_0 is rotated against A_0A through the angles α in counterclockwise direction (opposite to the direction of rotation of crank A_0A against A_0B_0), thus bringing B_0 to the positions B_{02}, B_{03} and B_{04}. Since the position of joint B is unknown, and since only the angles of rotation β_1, β_2 and β_3 of the plane of member B_0X are known, a distance B_0X_1 representing this plane may be assumed. By rotating this distance through the angles β, X_2, X_3, X_4 are obtained, indicating the positions of the plane. If this plane is rotated, along with A_0B_0, counterclockwise about A_0 through the angles α, the points X_2', X_3', X_4' are located. Thus, relative to member A_0A, the member B_0X assumes the new positions $B_{02}X_2'$, $B_{03}X_3'$ and $B_{04}X_4'$. In addition, point A_1 must be a center of a circle on which a point of the plane lies in these four positions. If this point of the plane is to be the joint B, the curve of Burmester's centers is designed for the four positions of the plane. Since this curve is developed over the poles of rotation of the plane and is not dependent on certain points of the plane, the points B_0, B_{02}, B_{03}, B_{04}, X_1, X_2', X_3' and X_4' may be used to locate the poles. The point A_1 of the curve of Burmester's centers may be found as the point of intersection of circles k_x and k_y, *Fig.* 5*a*, by the method already illustrated in *Fig.* 4. This point may be taken as position A_1 of joint A.

With the center at A_0, the circle through A_1 is drawn and A_2, A_3 and A_4 are found by drawing the angles α_1, α_2 and α_3 at A_0A_1. To find the position B_1 of joint

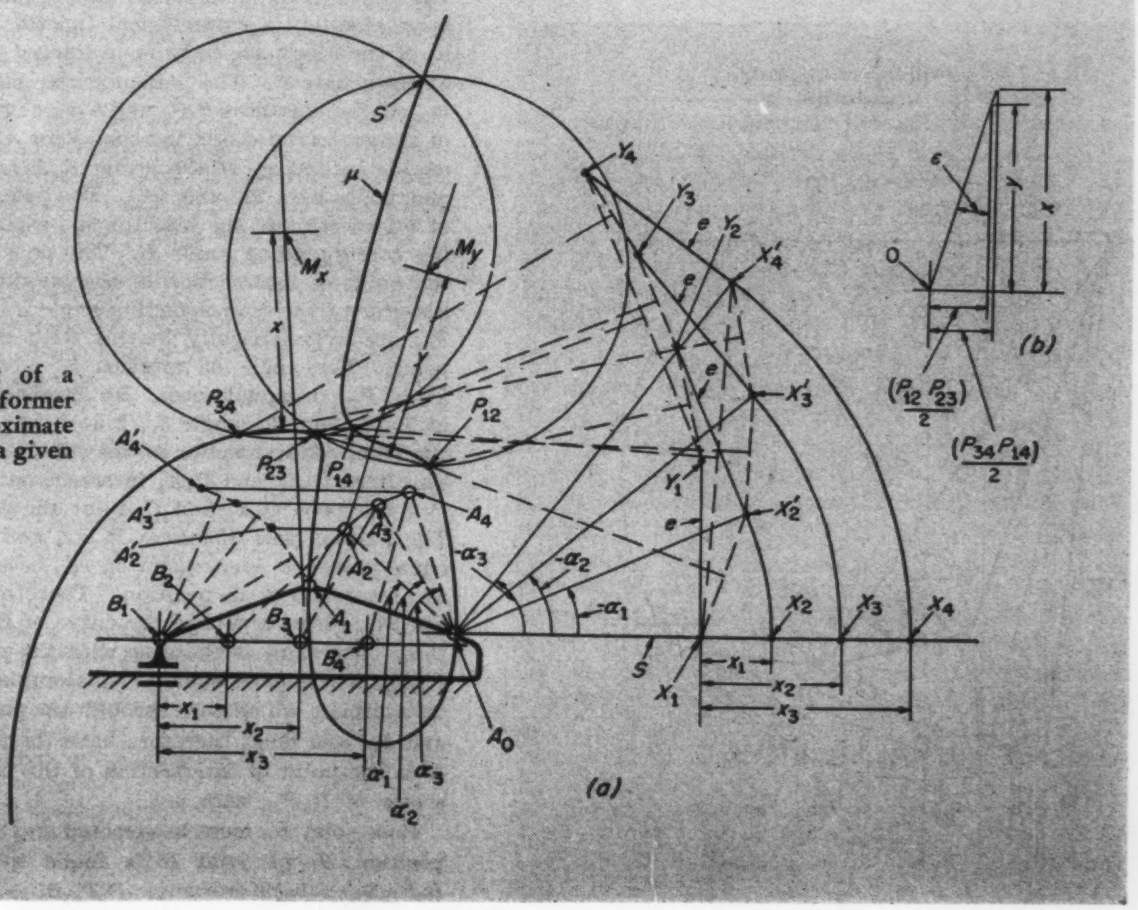


Fig. 6—Layout of a harmonic transformer for the approximate performance of a given function

B, B_0A_3 is rotated counterclockwise through B_2 to positions B_0A_3' and B_0A_4 and through β_3 into position B_0A_4'. Then, on A_1A_3' and $A_3'A_4'$, the perpendicular bisectors which intersect at the desired point B_1 are drawn. Thus, the linkage is complete.

Harmonic Transformer Layout: The same procedure used in *Fig.* 5 may be applied to draw the layout of a harmonic transformer, *Fig.* 6, for the approximate performance of a given function. This transformer is only a special case of a four-bar linkage with a base joint at infinity. The function reads here as $x = f(\alpha)$ where x is the stroke of the slide and α is the crank angle.

To start the drawing, the base joint A_0, *Fig.* 6*a*, and the direction of the motion of the slide must be assumed. The three strokes x_1, x_2 and x_3 and angles α_1, α_2 and α_3 are given. These represent four values of the function by the crank positions A_1 to A_4 and the slide positions B_1 to B_4. The member B_0B of *Fig.* 5*a* is represented in *Fig.* 6*a* by the slide and its plane, while the former base member A_0B_0 is represented by the slide line of action s. The point X_1 of the plane of the slide may be located on the line s at any assumed distance from A_0. The points X_2, X_3 and X_4 must be located in the same line s at the given distances x_1, x_2 and x_3. To draw the bisectors needed for location of the poles P another point Y_1 is chosen on the same plane of the slide, perpendicular to s at X_1 and at a distance e. If the transformer crank rotates clockwise, the plane of the slide should be rotated counterclockwise through the angles $-\alpha_1$, $-\alpha_2$ and $-\alpha_3$, bringing the points X_2, X_3, X_4 into the positions X_2', X_3' and X_4', the point Y_1 into the positions Y_2, Y_3 and Y_4. The points X_1, X_2', X_3', X_4', Y_1, Y_2, Y_3 and Y_4 locate the poles P_{12}, P_{23}, P_{14} and P_{34}. The points S of the curve of Burmester's centers are found at the intersections of circles with centers M_x and M_y, *Fig.* 4. After drawing the curve, point A_1 is chosen and the circle about A_0 through A_1 is drawn. From the angles α_1, α_2 and α_3, the positions A_2, A_3 and A_4 of the crank are found. To locate B_1, point A_2 is moved parallel to s through $-x_1$ to A_2', point A_3 through $-x_2$ to A_3', and for a check point, A_4 through x_3 to A_4'. The three perpendicular bisectors of A_1A_2', $A_2'A_3'$ and $A_3'A_4'$ must then intersect in the same point B_1.

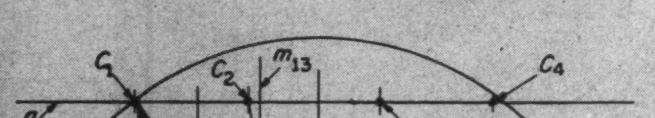
If the transformer, thus completed, does not show favorable dimensions, another point of μ may be chosen as point A_1.

With the help of two curves of Burmester's centers a harmonic transformer for four given ratios, x/α, or five values of the given function, may readily be designed.

Special Cases: The curve of Burmester's centers will degenerate into a straight line and circle if the poles are located in a symmetrical position. In *Fig.* 7, a four-bar linkage for a straight line motion is laid out with the positions of C_1, C_2, C_3 and C_4 assumed on a straight line in symmetrical positions. To perform approximately a symmetrical function, angles α_1 and α_2 of the crank are to be co-ordinated to the distances of the points C. The perpendicular bisectors m_{14} and m_{23} of the distances C_1C_4 and C_2C_3 coincide in the axis of symmetry on which the base joint A_0 is chosen. The angles α_1 and α_2 of the crank A_0A are located symmetrically with the axis m_{14}. The pole P_{12} is the point of intersection of the bisector m_{12} with the bisector of the corresponding angle α_1. The pole P_{13} is found as the point of intersection of the bisector m_{13} with the bisector of the corresponding angle $\alpha_1 + \alpha_2$. P_{24} and P_{34} are symmetrically located with respect to these poles. The angle of rotation δ_{12} about P_{12} and δ_{13} about P_{13} are now known. By drawing the angle $\delta_{12}/2$ at $P_{12}A_0$ and the angle $\delta_{13}/2$ at $P_{13}A_0$, A_1 is found as the point of intersection of the sides of the two angles. The lines C_1A_1 and C_4A_4 intersect on m_{14} at the pole P_{14}, the lines C_2A_2 and C_3A_3 at the pole P_{23} on m_{23}. The pair of pole distances $P_{12}P_{14}$ and $P_{23}P_{34}$ subtend equal angles at every point on m_{14} because P_{12} and P_{34} are symmetrical in position. Therefore, the straight line m_{14} forms a part of the curve of Burmester's centers. The same is the case with the pairs $P_{13}P_{14}$ and $P_{23}P_{24}$. These pairs subtend equal angles at every point on a circle μ which goes through the points P_{12}, P_{13}, P_{24} and P_{34} and must therefore have its center M on m_{14}. M is the point of intersection of the perpendicular bisector of $P_{12}P_{13}$ with m_{14}.

Base joint B_0 must be selected on the circle μ. The position B_1 of joint B is found by making angle $B_0P_{12}B_1 = \delta_{12}/2$ and angle $B_0P_{13}B_1 = \delta_{13}/2$.

Fig. 7—Co-ordination of crank angles to the straight-line motion of a four-bar linkage



MACHINE DESIGN
Data Sheet

Centrifugal Pumps

Charts predict effects of changes in speed and size of homologous units

By Arvid E. Roach
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TWO problems frequently arise in the application of centrifugal pumps. They are:

1. Given the head-quantity characteristics of a pump which is operating at best efficiency at some speed N_1, what will be its best efficiency characteristics at some other speed N_2?
2. Given the best efficiency characteristics of a pump of some size D_1, what will be the best efficiency characteristics of a similar pump of some other size D_2?

Although there is presently no satisfactory general theory for centrifugal pumps, simple and reliable answers to these problems may be obtained from the affinity laws for homologous pumps—pumps which are exact geometrical images of each other.

Affinity Laws: The efficiency η of a centrifugal pump is a function of liquid quantity Q which passes through the pump in unit time, pressure p developed by the pump, speed N and size D of the pump, and the density ρ and viscosity μ of the liquid. Thus

$$\eta = f\,(Q, p, N, D, \rho, \mu) \qquad (1)$$

where f is some function of unknown form. It is known, however, that the form of f is the same for all homologous pumps.

Nomenclature

D = Diameter of pump impeller, in.
H = Head developed by pump, ft
N = Speed on pump impeller, rpm
P = Power required by pump, hp
Q = Quantity of liquid flowing through pump in unit time, gpm
g = Acceleration of gravity, ft per sec^2
p = Pressure developed by pump, psi
γ = Specific weight of liquid, lb per ft^3
η = Efficiency of pump
μ = Viscosity of liquid, slug per ft-sec
ρ = Density of liquid, slug per ft^3

From dimensional analysis, Equation 1 may be rewritten to relate dimensionless products, or

$$\eta = F\left(\frac{Q}{ND^3}, \frac{p}{\rho N^2D^2}, \frac{\rho ND^2}{\mu}\right) \qquad (2)$$

where again F is some function which, though unknown in form, is unchanging for homologous pumps.

For most pump calculations it is more convenient to work with head H than with pressure p. Since $p = H\gamma$ and $\gamma = \rho g$, Equation 2 may be written in the form

$$\eta = F\left(\frac{Q}{ND^3}, \frac{gH}{N^2D^2}, \frac{\rho ND^2}{\mu}\right) \qquad (3)$$

Then, for two homologous pumps denoted by subscripts 1 and 2, the efficiencies are

$$\eta_1 = F\left(\frac{Q_1}{N_1D_1{}^3}, \frac{gH_1}{N_1{}^2D_1{}^2}, \frac{\rho_1N_1D_1{}^2}{\mu_1}\right) \qquad (3a)$$

$$\eta_2 = F\left(\frac{Q_2}{N_2D_2{}^3}, \frac{gH_2}{N_2{}^2D_2{}^2}, \frac{\rho_2N_2D_2{}^2}{\mu_2}\right) \qquad (3b)$$

For dynamic similarity of homologous centrifugal pumps, $\eta_1 = \eta_2$, a condition which holds when

$$\frac{Q_1}{N_1D_1{}^3} = \frac{Q_2}{N_2D_2{}^3}, \quad \frac{gH_1}{N_1{}^2D_1{}^2} = \frac{gH_2}{N_2{}^2D_2{}^2},$$

$$\text{and } \frac{\rho_1N_1D_1{}^2}{\mu_1} = \frac{\rho_2N_2D_2{}^2}{\mu_2}$$

In theory this condition cannot be satisfied when both pumps handle the same liquid (that is, when $\rho_1 = \rho_2$ and $\mu_1 = \mu_2$). In practice, however, this limitation need not arise because the performance of a centrifugal pump is independent of the argument $\rho ND^2/\mu$ (Reynolds' number) as long as the flow through the pump is completely turbulent. Complete turbulence is expected in all centrifugal pumps handling water, gasoline, and other light liquids. For pumps handling very viscous liquids, such as lubricating oils, the flow may not be completely turbulent. In that case the pump characteristics will be affected by Reynolds' number, and the simplified solution presented in this data sheet will not then be applicable.

Under conditions of completely turbulent flow, therefore, the affinity laws for homologous pumps operating at the same efficiency then reduce to

$$\frac{Q_1}{N_1D_1{}^3} = \frac{Q_2}{N_2D_2{}^3} \qquad (4)$$

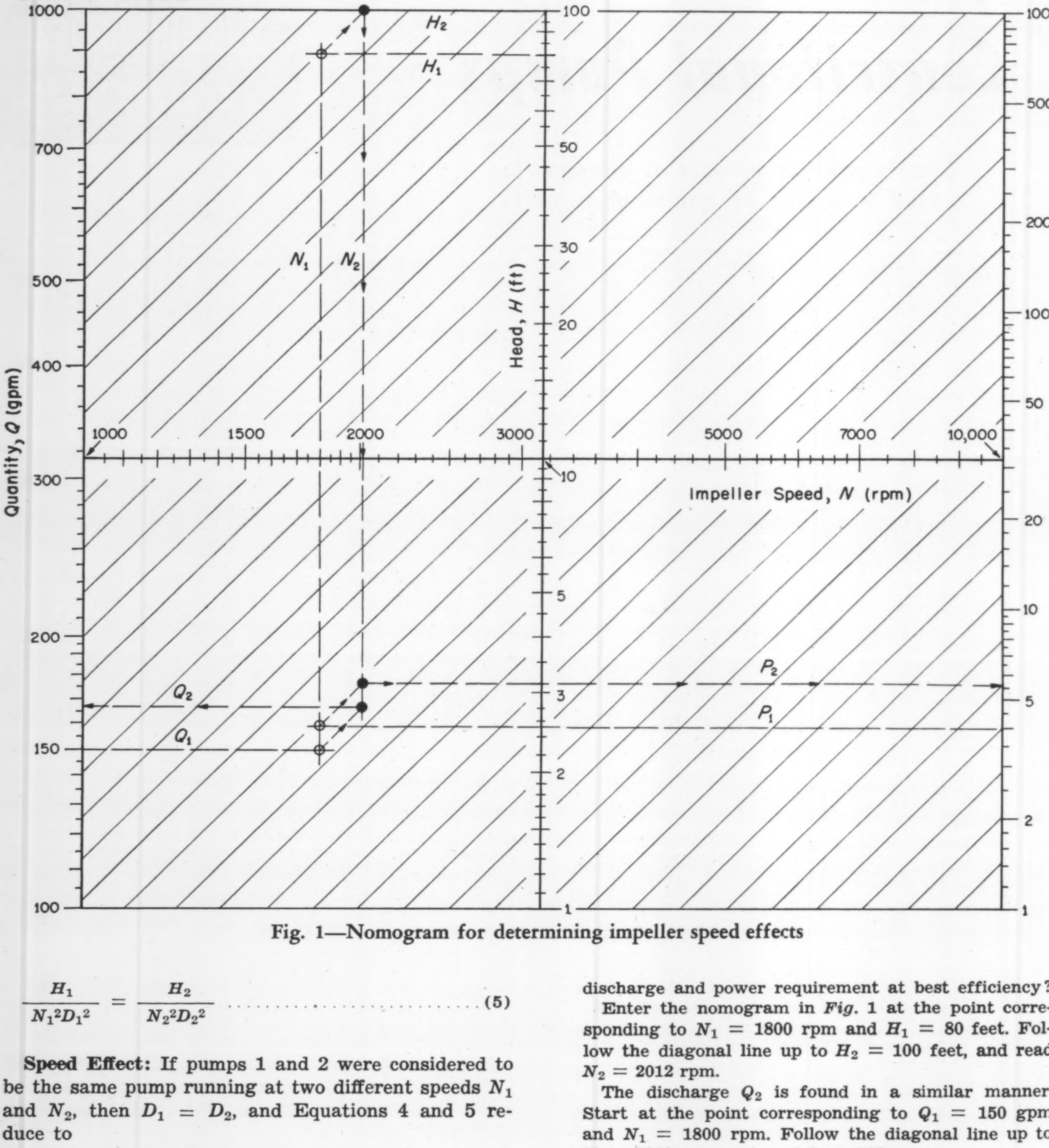

Fig. 1—Nomogram for determining impeller speed effects

$$\frac{H_1}{N_1^2 D_1^2} = \frac{H_2}{N_2^2 D_2^2} \quad \ldots\ldots\ldots\ldots (5)$$

Speed Effect: If pumps 1 and 2 were considered to be the same pump running at two different speeds N_1 and N_2, then $D_1 = D_2$, and Equations 4 and 5 reduce to

$$\frac{Q_1}{Q_2} = \frac{N_1}{N_2} \text{ and } \frac{H_1}{H_2} = \left(\frac{N_1}{N_2} \right)^2$$

Therefore with homologous pumps of the same size, Q varies directly as N, and H varies as N^2.

The power P required to drive the pump is proportional to the product of Q and H; hence, P varies as N^3 for homologous pumps of the same size handling the same liquid as shown in *Fig.* 1.

EXAMPLE 1: A centrifugal pump has its best efficiency when running at 1800 rpm and discharging 150 gpm of water against a head of 80 feet. Under these conditions the power consumption is 4 hp. It is desired to increase the head to 100 feet. At what speed must the pump be run, and what will be its discharge and power requirement at best efficiency?

Enter the nomogram in *Fig.* 1 at the point corresponding to $N_1 = 1800$ rpm and $H_1 = 80$ feet. Follow the diagonal line up to $H_2 = 100$ feet, and read $N_2 = 2012$ rpm.

The discharge Q_2 is found in a similar manner. Start at the point corresponding to $Q_1 = 150$ gpm and $N_1 = 1800$ rpm. Follow the diagonal line up to $N_2 = 2012$ rpm, and read $Q_2 = 168$ gpm.

To find the power consumption P_2, start at the point corresponding to $P_1 = 4$ hp and $N_1 = 1800$ rpm and follow the diagonal line up to $N_2 = 2012$ rpm, and read $P_2 = 5.6$ hp.

Size Effect: For homologous pumps of different sizes ($D_1 \neq D_2$), but running at the same speed, Equations 4 and 5 reduce to

$$\frac{Q_1}{Q_2} = \left(\frac{D_1}{D_2} \right)^3 \text{ and } \frac{H_1}{H_2} = \left(\frac{D_1}{D_2} \right)^2$$

Therefore with homologous pumps running at the same speed, Q varies as D^3, and H varies as D^2. The power P required by the pump then varies as D^5.

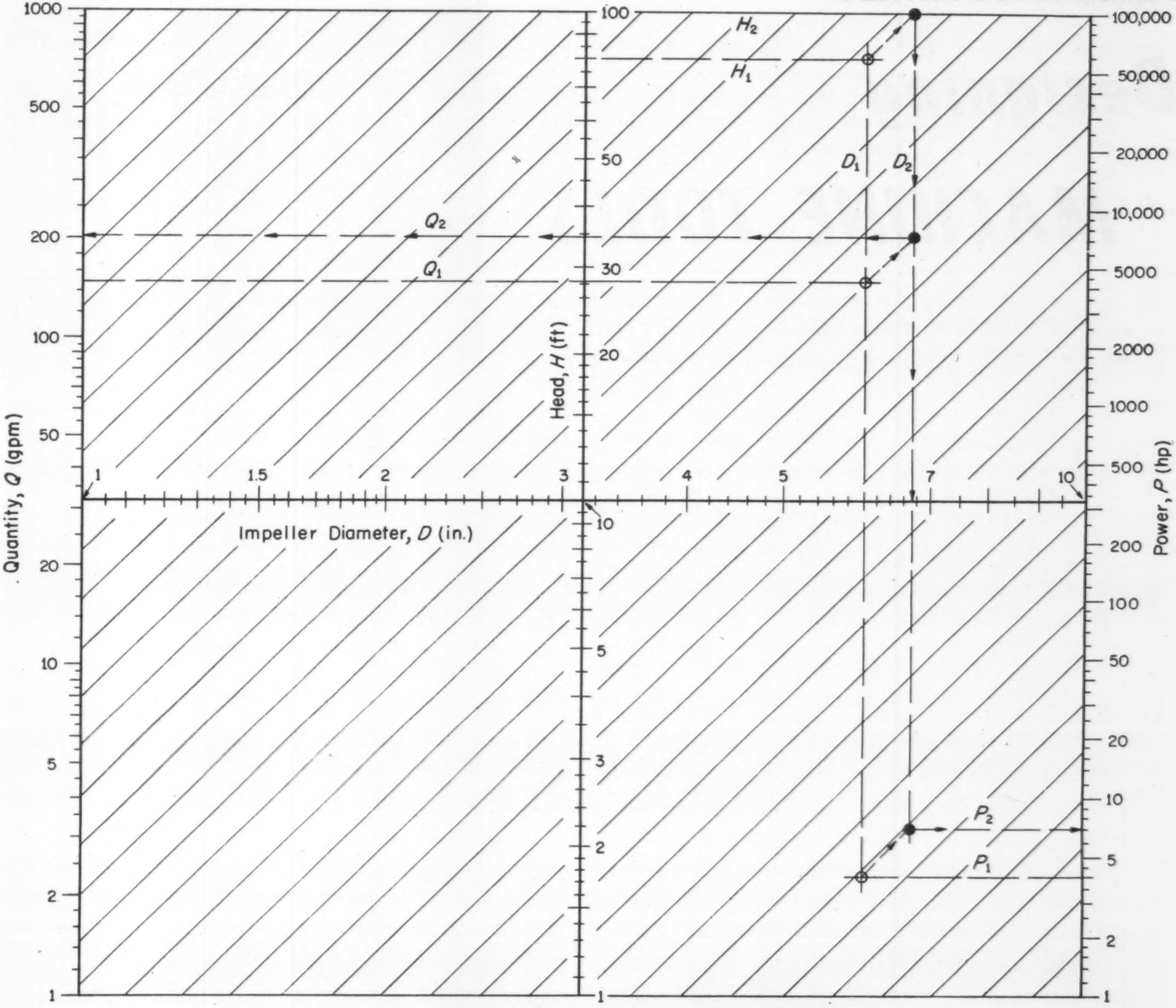

Fig. 2—Nomogram for determining impeller size effects

These relationships are represented graphically by *Fig.* 2.

Example 2: A centrifugal pump having an impeller diameter of 6 inches discharges 150 gpm of water against a head of 80 feet when running at 1800 rpm. Under these conditions the power consumption is 4 hp. How large must the impeller diameter be to develop a head of 100 feet at the same speed, and what will be the discharge and power requirement under this condition?

Enter the nomogram in *Fig.* 2 at the point corresponding to $D_1 = 6$ inches and $H_1 = 80$ feet. Follow the diagonal line to $H_2 = 100$ feet, and read $D_2 = 6.7$ inches. By similar procedures, $Q_2 = 210$ gpm and $P_2 = 7$ hp.

Sources of Error: The principal sources of error are, first, errors in measured values (subscript 1) which cause corresponding errors in predicted values (subscript 2) and, second, failure to satisfy fully the requirement of perfect geometrical similarity.

When it is desired to predict the effect of a change in speed of a given pump (as in example 1), the requirement of perfect geometrical similarity is fully satisfied. Errors in predicted performance (subscript 2) will then result only from errors in measured performance (subscript 1), and the effects of such errors are readily determined from Equations 4 and 5 or from the nomograms.

However, when it is desired to predict the effect of a change in scale of homologous pumps (as in example 2), the requirement of perfect geometrical similarity can rarely, if ever, be fully satisfied. Perfect geometrical similarity implies not only that all corresponding angles be the same and that all corresponding linear dimensions be in the same ratio to each other, but that all clearances and all surface roughnesses also be in the same ratio to each other. Therefore perfect geometrical similarity means geometrical similarity of microscopic details. Although a quantitative evaluation of these effects cannot be made now, it has been found from experience that as long as the change in scale does not exceed ±25 per cent, the errors in predicted performance are not likely to be greater than 2 or 3 per cent.

Designing MACHINE TOOLS

...for efficient co-ordination of electrical, hydraulic and mechanical components

By Kurt O. Tech
The Cross Co.
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TO MAKE machines function efficiently, electrical design must be co-ordinated closely with mechanical and hydraulic design, *Fig.* 1. A lack of this type of co-ordination and the completion of either the mechanical or the electrical designs with little thought to the other problems will not only result in a machine requiring excessive down time, but will also result in a sacrifice of automatic control efficiency and safety.

Basic Considerations: The electrical designer has an important role in achieving this objective. First, he makes sure that all other designers understand the part to be played by electric controls. Then, before proceeding with the development of the circuit, he reaches an agreement on the basic plans which may affect the work of all. A choice of either an electric or fluid motor or a limit switch and four-way valve control as opposed to a sequence valve are simple examples of the type of decisions to be made. Certainly this is the time to discuss and tentatively decide on the location of the various types of controls on and around a machine.

Fig. 1—Representative of present progress in machine tool design, this Cross Transfermatic performs 170 operations on an automotive cylinder block

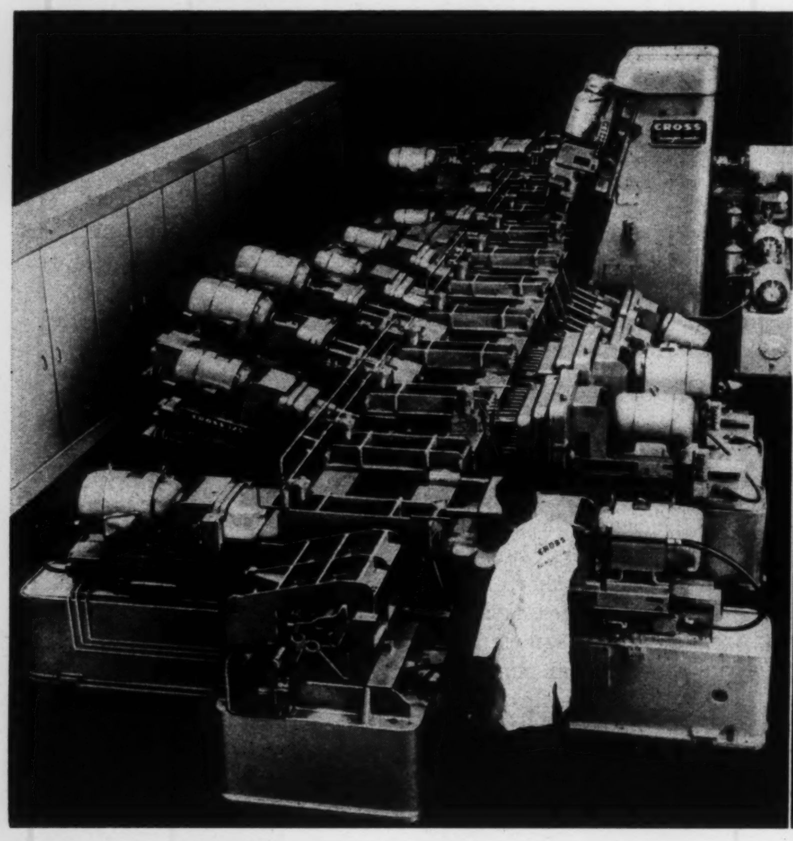
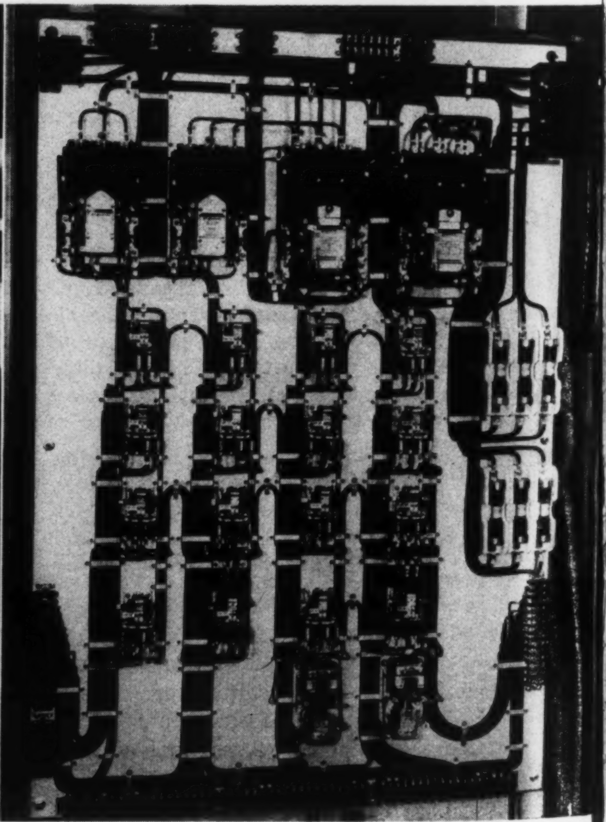


Fig. 2 — Logical sequence of panel mounted controls to tie in with machine operation facilitates maintenance and reduces down time



Two basic principles are to be followed in the development of any electrical circuit:

1. Control circuits for machine tools should be kept simple. In most large complex equipment they merely represent a repetition of similar functions.
2. Physical layout of the control equipment should parallel the simplicity of the circuit. Components should be so arranged that they can be easily identified as to function and readily serviced.

Certain design and co-ordinating work is required in the development of a machine tool, but consider the three basic divisions in the control circuit individually.

Panel-Mounted Controls: First are the controls consisting of the motor starters, relays, timers, etc. Upon signal from the machine-operated control they actuate electrical devices which in turn actuate hydraulic or electric power means on the machine.

Another important principle of control circuit development is that panel-mounted controls should be arranged in a logical sequence to tie in with the operation of the machine. A result of efforts so directed is shown in *Fig.* 2. In each section of the control panels, each vertical row contains all of the controls for a one way type hydraulic feed unit on a special machine tool. This unit has a saddle or head moved on ways by a hydraulic cylinder with hydraulic circuit provisions to permit rapid advance, two rates of feed, a dwell and rapid return. Except for starter sizes, these groups are identical. This arrangement facilitates maintenance because the electrician knows that the same relay of each group performs the same function. A panel controlling twenty units on a machine can be treated as twenty identical circuits, each with five pieces of equipment rather than a large complex circuit involving 100 pieces of equipment. Proper markings of this control equipment, so that an identical control relay in each circuit carries the same number, further facilitates simplicity and maintenance.

But in addition to these design problems involving panel arrangements and identification of units, the electrical cabinet should be located in a position where wiring runs will be the simplest. Also, it must be where the machine and its operations are most visible to the electrician maintaining the panel. Too, the panel should be completely protected from any damage resulting from machine operation, not in any space which happens to be left after all other equipment has been located.

Machine-Mounted Controls: The second phase of control circuits consists of electrical controls which are mounted on the machine. They may be classified broadly into two groups, each of which has a close relationship with the mechanical portions of the machine.

The first group consists of pushbuttons, limit switches, zero-speed switches, etc., which react to manual or mechanical operations to carry signals to control units on the control panel. Second group of controls includes solenoids such as are used to shift spools in hydraulic valves and to operate other apparatus on the machine.

It is in the determination, the actuation and the location of such controls that the electrical designer does the most toward obtaining an integrated and trouble-free design. When complex interlock circuits are required on a machine, he suggests looking into ways in which mechanical connections can be used to eliminate electrical interlocks. For example, twenty locating pins may be entered simultaneously into ten parts of a transfer machine. It is usually better to consider interlocking these pins mechanically to permit one power source and two limit switches. One switch indicates the entrance of the pins into their respective blocks and the other indicates their withdrawal. The electrical alternative to this design requires at least twenty limit switches.

The electrical designer makes sure that the important factors influencing the location of machine-mounted controls are considered. The first is to mount equipment so it can perform efficiently without

(*Continued on Page* 294)

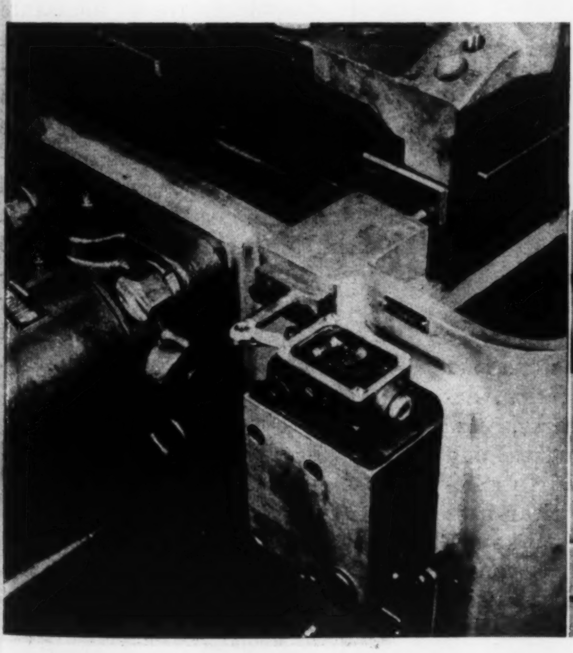
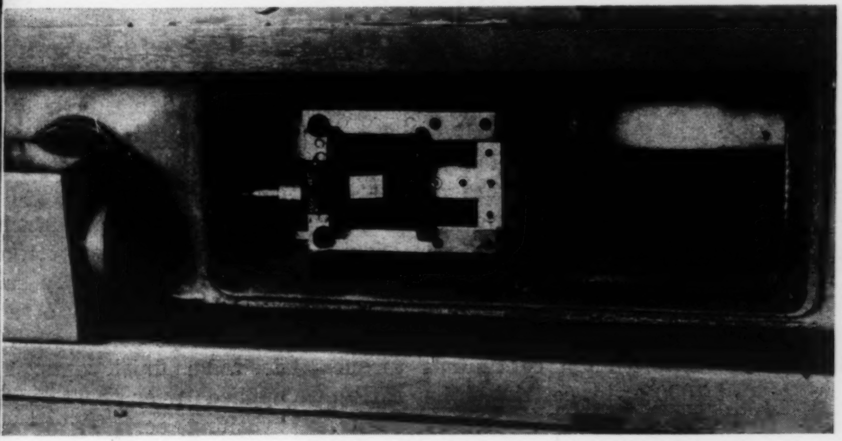


Fig. 3—Left—Simple mechanical connection used to operate this manifold-mounted limit switch provides easy accessibility and simplifies repair and replacement problems

Fig. 4—Below—Separate mounting of this solenoid provides protection from fluid fouling and simplifies disassembly and maintenance

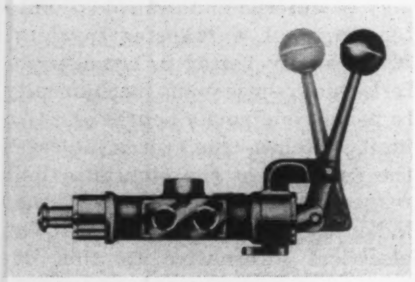


NEW PARTS

AND MATERIALS

For additional information on these new developments, see Page 219

Air Control Valves

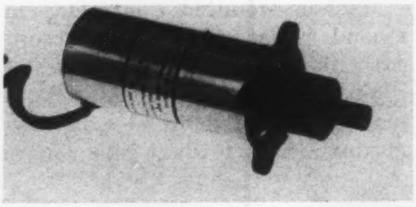


Built-in speed controls simplify piping of this valve by eliminating piping needed with separate speed control valves. Principally used to control the stroke of an air cylinder, the current production model is a 4-way piped exhaust model with $\frac{3}{8}$-in. IPT ports. Knob, lever, clevis, treadle, cam, solenoid and diaphragm actuators are available. Valve without actuator is $7\frac{9}{16}$ in. long and $3\frac{15}{16}$ in. wide. Made by **Valvair Corp.**, 454 Morgan Ave., Akron, O.

For more data circle MD-1, Page 219

Miniature Gearmotors

Available in 18 different ratios between 17.8 to 1 and 21,808 to 1, these small gearmotors consist of a planetary reduction gear unit and a 1/50 or 1/100 hp dc motor. Diameter of the units is $1\frac{1}{4}$ in.; maximum length is $3\frac{11}{32}$ in. Torque available varies with the reduction up to a maximum continuous torque of 1000 oz-in. for the higher ratios. Backlash is held to close limits. The standard unit is available with four-hole flange mounting and $\frac{5}{16}$-in. diameter shaft extension, $\frac{1}{2}$-in. long. The unit is furnished with gear train and motor completely enclosed in one integral cover. All assemblies are heat treated for maximum performance. Output shaft and last stage carrier are made in one integral piece for maximum reliability. All gears are precision cut for smooth performance and maximum efficiency. Units can be supplied for most standard voltages by **Globe Industries Inc.**, 125 Sunrise Place, Dayton 7, O.



For more data circle MD-2, Page 219

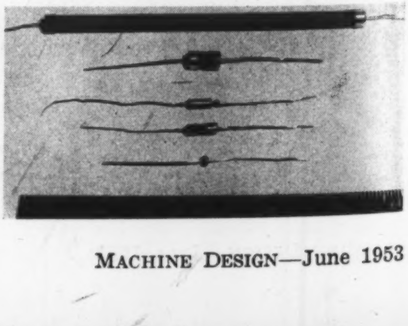
Rust-Resistant Paint

Now available in red, gray and green in addition to black, aluminum and clear, Rustrem stops rust completely in one application, according to the manufacturer. For use on all metals, both indoors and out, these paints are said to eliminate the necessity of a clear base coat except where other paints are desired as finish coats. They can be applied over rust without wire brushing, scraping or sandblasting by brush, spray, dip or roller. They are said to penetrate rust layers and adhere tightly to surfaces beneath, forming a tight seal which resists moisture, temperature changes, chemicals, acids and fumes. Rustrem can be effectively applied over damp surfaces, since the paint penetrates through moisture and adheres firmly to the metal below. Available in $\frac{1}{2}$-pint, pint, quart, gallon, 5-gallon and 55-gallon containers from **Speco Inc.**, 7308 Associate Ave., Cleveland 9, O.

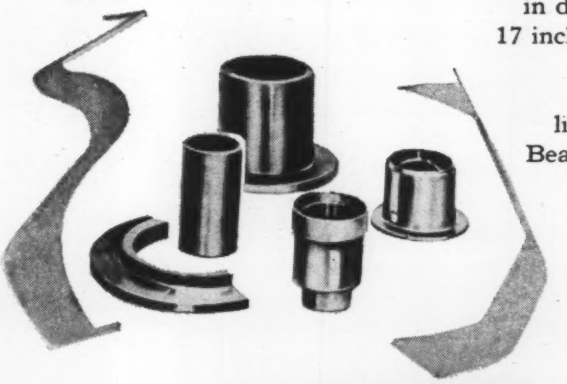
For more data circle MD-3, Page 219

Miniature Rectifiers

Designed as nonexpendable components for industrial and government equipment, these miniature selenium rectifiers can operate small relays, solenoids and precipitators. Range of size from $\frac{3}{32}$ to $\frac{15}{32}$-in. in diam; applications include computer, signal, magnetic amplifier, communication, and control circuits. The assemblies have an ambient temperature range of −55 C to +100 C. At an ambient temperature of 35 C, the single-stack rating ranges from 0.5 ma dc at 26 v rms to 25 ma dc at 5200 v rms.



Johnson CAST BRONZE BEARINGS HAVE UNTOLD APPLICATIONS



There are thousands of applications where sleeve bearings cast from bronze alloys are the most practical, serviceable and economical. For over fifty years Johnson Bronze has been recognized as an outstanding source of supply for these bearings. Every month an immense quantity of cast bronze bearings is produced . . . in numerous styles and in a great range of sizes. Tiny bearings, ¼ inch or less in diameter, to "king size" bearings, 14 inches OD and 17 inches in length, are included in this huge production. Over 900 sizes of Johnson General Purpose GP Bearings are available from distributors' stocks; likewise a wide selection of Graphited Cast Bronze Bearings and over 340 EM Electric Motor Bearings. For special applications, Johnson engineers will gladly consult with you on style of bearing and alloy best suited and, if necessary, will help you design the bearing best suited to your needs.

JOHNSON BRONZE COMPANY
525 South Mill Street, New Castle, Pa.

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JOHNSON JB BEARINGS
Sleeve-Type

JOHNSON BRONZE PRODUCES ALL TYPES OF SLEEVE BEARINGS:
CAST BRONZE, plain or graphited • BRONZE-ON-STEEL, copper-lead • STEEL BACK, babbitt lined • BRONZE BACK, babbitt lined • SHEET BRONZE, plain or graphited • CAST ALUMINUM • ALUMINUM-ON-STEEL • LEDALOYL powder metallurgy

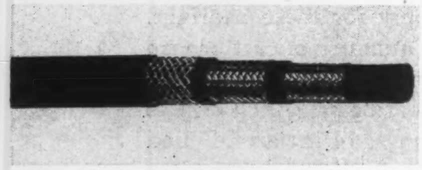
Sleeve Bearing Headquarters since 1901

Higher ratings can be obtained by combining the stacks. Two totally enclosed types of castings are available: Textolite tubes, and hermetically sealed, metal-clad casings. Although standard design is for lead mounting, cells may be bracket mounted. Developed by **General Electric Co.,** Lighting and Rectifier Dept., Schenectady 5, N. Y.

For more data circle MD-4, Page 219

Hydraulic Control Hose

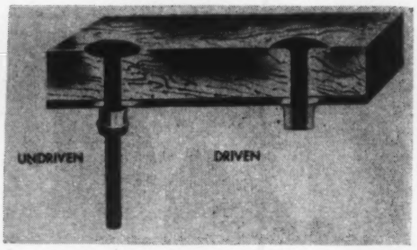
Reinforcement with high-tensile steel wire gives high flexibility and burst resistance under shock loads to this hydraulic control hose. Specially compounded rubber resists all common hydraulic fluids and remains flexible at temperatures from −40 to 250 deg F. Rubber cover is cross-wrapped to protect the carcass against weather, mildew, oil, grease and fumes. Sizes from 3/16 to 2 in. ID are available. Made by **Quaker Rubber Corp.,** Div. H. K. Porter Co. Inc., Tacony and Comly Sts., Philadelphia 24, Pa.



For more data circle MD-5, Page 219

Wood-to-Metal Fastener

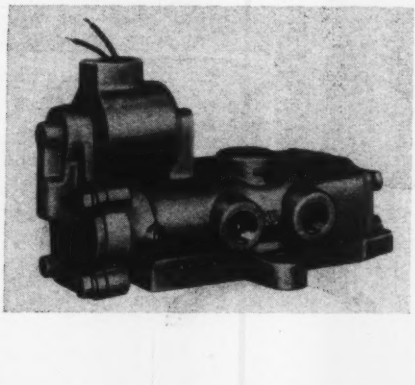
A new fastener, called the R-1018 Commercial Lockbolt, is for permanent wood to metal fastening at assembly speeds up to 2000 completed fastenings per hour with a pneumatic pull gun. Available in 3/16 and 1/4-in. diameters. The pin portion is fabricated from mild steel and the collar from 61S aluminum alloy. Using the gun, the work is automatically pulled tightly together in a continuous operation sequence as follows: Insert Lockbolt pin through prepared hole in work; slip collar over pintail and apply nose of pull gun to pintail. Pulling jaws in the pull gun engage grooves in pintail, and when the trigger is depressed, the tool simultaneously pulls on the pintail while pushing against the collar to draw the pin into the hole and squeeze the work together. In quick sequence the collar is then swaged into locking grooves, and the portion of pintail protruding beyond the locked collar is broken off and ejected. Typical applications are attachment of wooden slats to vertical stakes in truck stake body construction, wooden floor and siding attachment for trucks, trains, etc., as well as a positive means of attaching hardware to wooden members. Made by **Huck Mfg. Co.,** 2480 Bellevue Ave., Detroit 7, Mich.



For more data circle MD-6, Page 219

Four-Way Solenoid Valve

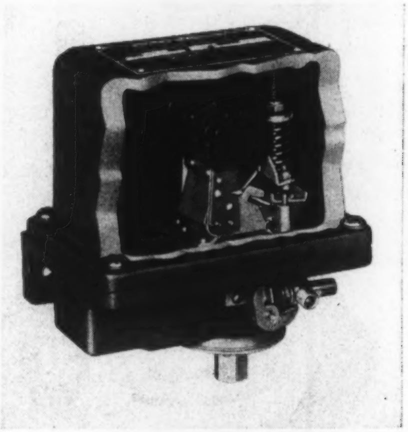
Merely replacing rear plate changes a new four-way packless poppet solenoid valve to five-way operation. Valve operates at up to 750 cycles per minute intermittent duty, and up to 500 cycles per minute continuous duty, with air or gas as medium. It will also operate on oil or water. Especially suited to exacting machine tool and press service applications, the valve features bronze body; poppet type, beveled stainless steel seats and disks; guided, inserted seats (no threads); few moving parts; and short stroke. Main valve is power operated in both directions. Unit mounts in any position, and connections can be made to front, rear and top, or brought into bottom for pad-type mounting. Standard enclosure is watertight and explosionproof. Sizes are available for 3/8, 1/2, 3/4 and 1 in. pipe connection. Made by **Automatic Switch Co.,** 391 Lakeside Ave., Orange, N. J.

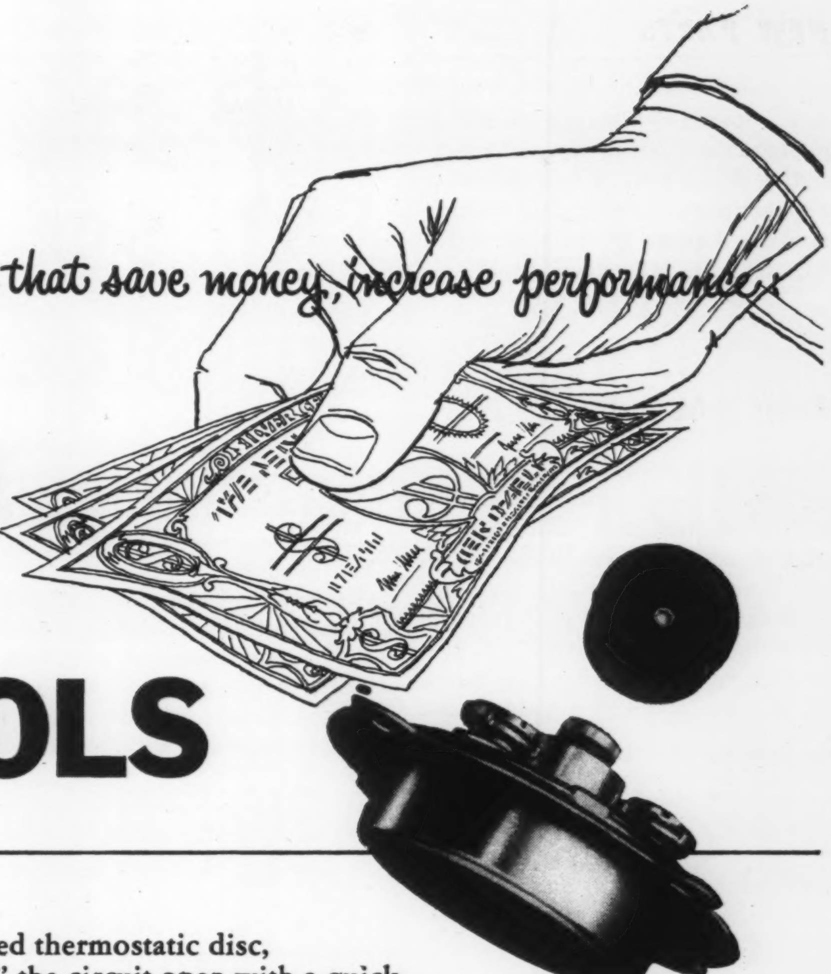


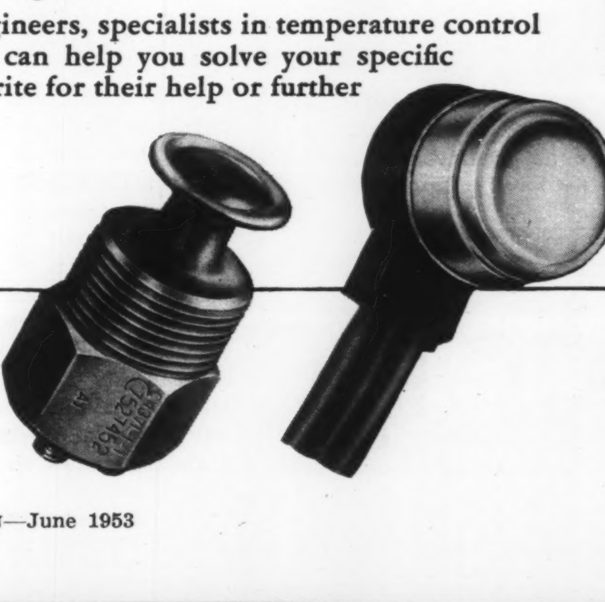
For more data circle MD-7, Page 219

Pressure Switch

Contained in an explosion-resisting enclosure, these newly developed switches are for use where explosive atmospheres are present or highly combustible fuels must be handled. Two distinct types are available to meet varying requirements. The water-pump switch has a 20 to 80 psi pressure range. The air-compressor switch has a 40 to 200 psi pressure range, and is available with a two-way release valve. Control is easily adjustable over the entire pressure range. The explosion-resisting enclosure consisting of a two-piece casting with highly machined surfaces between cover and case, has been designed to meet Class I, Group D specifications. Stationary contact block and the movable contact yoke bar are made of non-carbon tracking Rostone. Construction is two pole, double break, silver-to-silver, visible and vertical contact. The operating mechanism is of the positive snap-action type, insuring positive contact regardless of range or differential spring adjustment. Internal parts are treated to resist corro-







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Thermo-Snap

CONTROLS

Actuated by the scientifically calibrated thermostatic disc, Klixon disc-operated controls "snap" the circuit open with a quick, clean break — and "snap" it closed again to a solid make no matter how often they operate. Because Spencer Controls have no complicated relays, toggles, magnets or other fussy parts, their accurate performance is unaffected by shock, vibration, motion or altitude regardless of the position of mounting.

What's your temperature control problem . . . low and high limit controls, fuel delay switches, tube and rectifier cooling, fan switches, temperature control . . . Klixon Thermo-Snap Controls are meeting the requirements for these and other applications in military and civilian products, daily.

Klixon Thermo-Snap Controls are available in many hermetically sealed and open types in a wide variety of operating temperature ranges.

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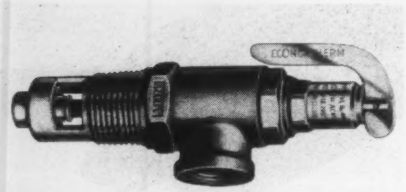
Division of Metals & Controls Corporation
2506 FOREST STREET, ATTLEBORO, MASS.

sion. Standard diaphragms are of impregnated fabric. Special oil-resisting diaphragms are available for applications requiring this feature. Made by **Square D Co.,** 4041 North Richards St., Milwaukee 12, Wis.

For more data circle MD-8, Page 219

Relief Valve

Econo-Therm relief valves offer automatic temperature and pressure protection from water heater explosions. Standard industrial relief pressure setting is 125 lb and standard temperature setting is 208 F. Other settings may be specified in this type V series which has a ¾-in. pipe inlet and a ½-in outlet.

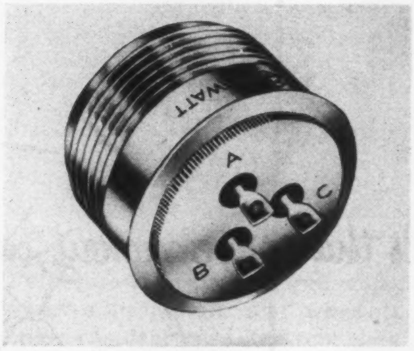


Available in either regular or stem type units with or without try levers. Made of bronze and utilizing stainless-steel springs and produced by **A. W. Cash Valve Mfg. Corp.,** 666 E. Wabash Ave., Decatur, Ill.

For more data circle MD-9, Page 219

Hermetically Sealed Connectors

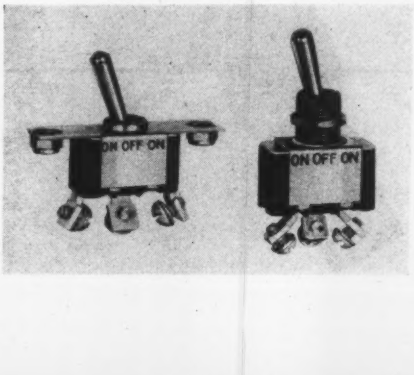
M-7500 series hermetically sealed connectors are said to give complete protection to circuits of hermetically sealed electronic and electrical instruments under extreme conditions. For example, they withstand mechanical shock of 100*g*, thermal shock from 500 F in oil to the temperature of liquid air, temperatures as high as 1500 degrees F and voltage of more than 1000 volts. They are impervious to moisture, corrosion, rare atmosphere, high pressure, fungus and vibrations. One end of the conector is designed to mate with standard AN (MIL) types. The other end has a tapered and serrated surface so connector can be pressed into instrument housing and mechanically anchored to prevent turning. The strength of this mechanical anchor plus the high melting temperature of the connector's hard-glass insulation permit use of any common method of bonding connector to housing—soft solder to welding—without the use of special assembly jigs and staking tools and without danger of breaking or melting the seal. Special models are available with special alloy shells and mounting arrangements for unique applications. Made by Monowatt Dept., **General Electric Co.,** 95 Hathaway St., Providence 7, R. I.



For more data circle MD-10, Page 219

Toggle Switches

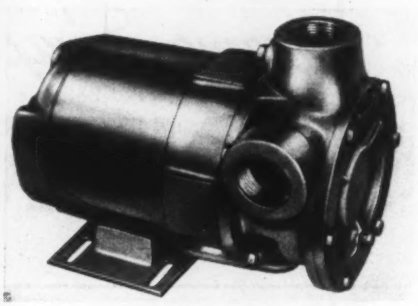
Nine single-pole switches in the 11TS series are bushing mounted, have a sealed toggle lever, and are offered with screw or solder type terminals. Ratings for this series are 20 amp resistive load at 30 v dc, 15 amp resistive load at 125 v ac (maintained contact version) and 15 amp resistive load at 30 v dc and 125 v ac (momentary contact version). A second series, the 31TS, includes eight three-hole mounting type single-pole toggle switches. Ratings are 40 amp resistive load at 30 v dc, 20 amp resistive load at 115 v ac (maintained contact type) and 30 amp resistive load at 30 v dc or 20 amp resistive load at 115 v ac (momentary contact type). All switches conform to AN and JAN specifications. Made by **Minneapolis-Honeywell Regulator Co.,** Micro Div., Freeport, Ill.



For more data circle MD-11, Page 219

Turbine Type Pumps

Available in capacities of 3 to 30 gpm and heads from 0 to 250 ft, Apco V-type close-coupled turbine pumps have mechanical seals and are available with self-priming features. Design assures compactness and permanent alignment. Cover, inner ring and impeller are made of bronze for protection against wear and corrosion. Pumps will handle vapor entrapped in liquid without losing their prime. Made by **Aurora Pump Co.,** 31 Dearborn St., Aurora, Ill.



For more data circle MD-12, Page 219

High-Purity Aluminum

Parts with a permanently lustrous high finish which will not tarnish or lose its luster even when submerged in salt water, are made possible by Lurium, aluminum metal that is 99.99 per cent pure. This high purity enables the surface of the metal to take on a higher polish and luster than is possible with less pure aluminum. Lurium is alloyed with varying percentages of magnesium for different applications. It is a work hardening alloy, easy to fabricate, and may be anodized and dyed in any color to simulate gold, silver, platinum, copper, brass or any other alloy. Available in all standard shapes, sheets, coils strips,

Facts about *HELI-COIL* inserts you should know

What they are

*Heli-Coil** screw thread inserts are precision formed coils of stainless steel or phosphor bronze wire. Wound into tapped holes, they form permanent, non-corrosive, strip-proof threads of astonishing strength. Available for National Coarse, National Fine and Unified threads, pipe threads and spark plug threads. They are made in all standard sizes and lengths for assemblies requiring Class 3, 3B, 2 or 2B fits.

What they are for

AS ORIGINAL COMPONENTS: *Heli-Coil* inserts are used to provide stronger, lighter fastenings, corrosion-proof, wear-proof threads in all assemblies.

FOR PRODUCTION SALVAGE: When conventional tapped holes are damaged in production, restore them on the line with *Heli-Coil* inserts. Get better-than-original strength with no increase in screw size and no tell-tale signs of rework.

FOR SPEEDY REPAIRS: When tapped threads wear, strip or corrode in service, renew them in minutes on location in shop or field with *Heli-Coil* inserts. No welding—no plugging—no secondary machining—no oversize screws.

How they work

Holes are drilled and tapped as you do for ordinary threads—then *Heli-Coil* inserts are wound into tapped holes by hand or power tools. Install in a few seconds, assure thread protection forever. Can be used in any metal wood or plastic.

No other method is so simple, effective and practical.

What they do for you

Heli-Coil inserts *save money* because they strengthen threads and make *fewer* smaller fastenings do the same holding job. They make *lighter* bosses and flanges practical and they *save weight* in two ways: (1) by permitting use of cap screws, instead of bolts and nuts; (2) by allowing use of smaller, shorter, fewer cap screws. *Heli-Coil* inserts *protect* your product from thread wear, galling and stripping for life in every kind of metal, in plastics or wood. They preserve customer good-will by preventing product failure, due to thread fault. *Heli-Coil* inserts improve the end product, cut rejects, salvage threading errors.

Best time to put *Heli-Coil* inserts benefits to your use is right at the designing board, as many leading manufacturers are doing. But to convince you of their many advantages ask for a working demonstration right on your production line. Write today! Complete information and engineering data is available in the *Heli-Coil* catalog. Use Coupon!

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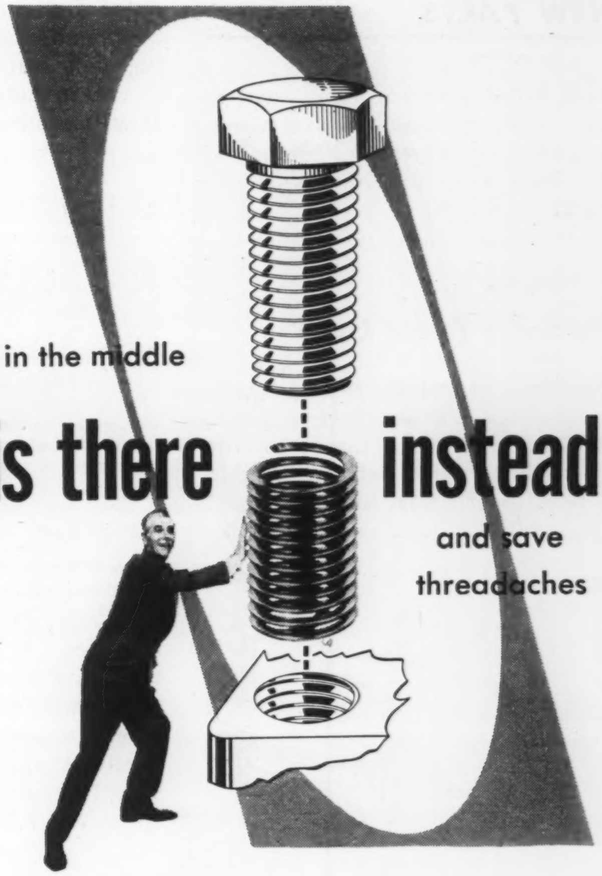
Approved for All Military and Industrial Uses

Advertisement

Don't get caught in the middle

put this there instead

and save threadaches



Sales demanding "twice the product at half the price"? Does production want "half the cost and half the time" on the production line? Where are you? Caught in the middle?

You can be a hero to both sales management *and* production management by telling them about *Heli-Coil** Screw Thread Inserts.

These precision formed inserts of stainless steel or phosphor bronze wire make vastly stronger threads in metal, plastics, and other materials. So much stronger that you can safely use smaller and fewer and shorter cap screws—thinner sections, lighter bosses. Thus costs are reduced, production simplified. And threads cannot strip, corrode or gall—they never wear out.

Learn how other designers are using *Heli-Coil* Screw Thread Inserts. Get the technical data you need to apply them to your "threadaches." Use the coupon—now!

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☐ **Send Free samples and Handbook No. 652, a complete design manual.**

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NAME__________ TITLE__________

COMPANY__________

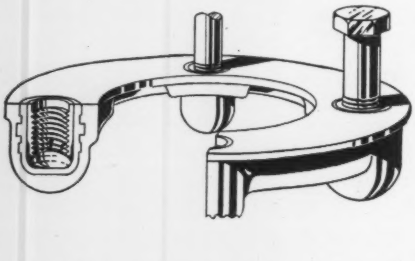
ADDRESS__________

CITY__________ ZONE_____ STATE______ 2102 bars, tubes, wire and extrusions, in soft, half hard and hard tempers. Imported by **Fromson Orban Co.,** 205 East 42nd St., New York 17, N. Y.

For more data circle MD-13, Page 219

Molded-In Thread Insert

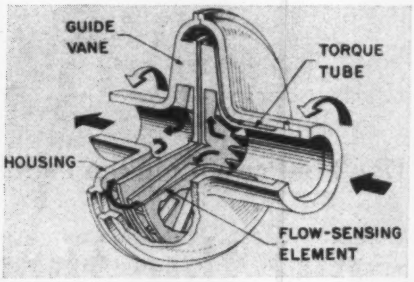
Designed for molding in softer metal castings and in plastics parts, this steel threaded insert affords clean threads and extreme holding power. Inserts have internal thread sizes of 10-32, ¼-28, or ⅜-24, with or without the Rosan locking feature and are furnace brazed into steel cap. Latter has two knurled flanges for torque resistance and large smooth flange to withstand axial loads. In tests, standard AN 10-32 bolts broke when 2900 to 3750 lb tensile loads were applied with no movement of the molded-in insert. Made by **Rosan Inc.,** 625 Coast Highway, Newport Beach, Calif.



For more data circle MD-14, Page 219

Mass Flowmeter

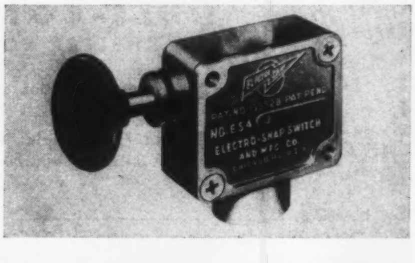
True mass rate of flow of anything that will flow or fall through a pipe can be measured by this flowmeter which responds to pounds, but is insensitive to volume. Direct readings in terms of pounds per minute, or with integration, pounds, can be made on gases, liquids, slurries or air stream particles. Accuracy is independent of volume, temperature, pressure, viscosity, compressibility, or external accelerations. Measurement is made of torque necessary to give flowing mass a Coriolis acceleration. This torque is dependent only on dimensions of flowmeter, a rotational speed and the mass flow. Two or more units used with a proportioning unit can control any mixture in an industrial process. Weight flow measurements in petroleum distribution systems for loading tank cars, or weight mixing control in chemical plants are other applications. Meter is custom built for each job. After most vital industrial and military needs are met first, units will be generally available. Developed by **Control Engineering Corp.,** 560 Providence Highway, Norwood 26, Mass.



For more data circle MD-15, Page 219

Industrial Limit Switch

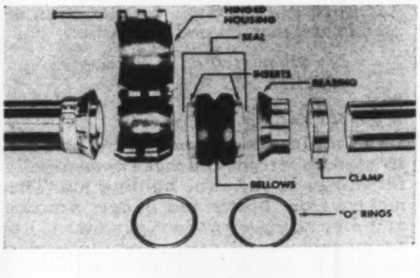
Designed to provide more inexpensive circuit controls by minimizing the need for relays in automatic sequencing or interlock operations, the type ES4-J limit switch has a die-cast case and integral plunger actuator. A 1¾ in. diam phenolic plastic button attached to the end of the actuator switch is available with constant contact action, which completes circuit as switch is actuated and breaks the circuit as actuating force is removed. Also produced is a one-way momentary contact model which sends an electrical impulse and then opens circuit for the rest of plunger's forward movement; switch is not tripped as plunger returns to its originally extended position. Electrical rating of switch is 10 amp at 125 v ac and is available as a single-pole, double-throw unit. Clearance dimensions including knob actuator and conduit connector are 3⅜ in. by 2⅝ in. by 1¾ in. Made by **Electro-Snap Switch & Mfg. Co.,** W. Lake St., Chicago 24, Ill.



For more data circle MD-16, Page 219

Tube Connector

A new tube connector, designated as Flex Joint, permits 10 degrees angular movement of the connected tubing with no leakage. Developed primarily to allow for aircraft wing flexing, the fitting absorbs vibration, allows axial expansion of connected tubing, and permits axial misalignment of $\frac{1}{16}$-in. No flaring or beading of the tubing is necessary and only ordinary hand tools are required to install this connector. Heart of the Flex Joint design is a synthetic rubber bellows bonded to aluminum inserts at both ends. Flexing and sealing are treated as two separate problems. The bellows permits relative motion of the inserts, and the inserts in turn contain two O-rings to seal against the tubing. Completing the assembly are a pair of bearings and clamps, and a housing. Both seals and O-rings can be replaced without tools. Connectors for 2-in. tubing are now being produced and sizes for 1 to 4-in. tubing will be available. Produced by **Aeroquip Corp.,** Jackson, Mich.

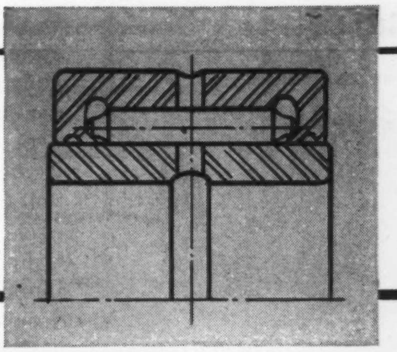


For more data circle MD-17, Page 219

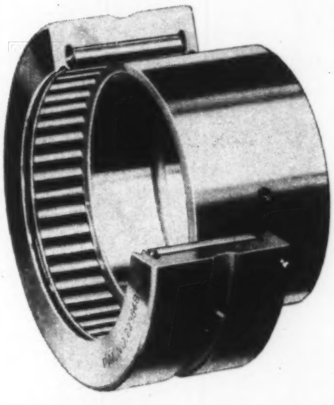
Magnetic Brakes

These fractional horsepower magnetic brakes are for all standard alternating or direct current mo-

A bearing design of simplified construction reduces internal wear

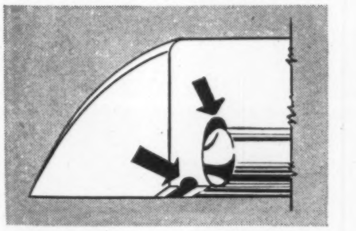


The performance efficiency and life expectancy of anti-friction bearings depends to a great extent on the ability of the bearing designers to hold internal wear to a minimum. They have found that wear can be materially lessened by reducing the number of bearing parts subjected to wear. In the case of MULTIROL SE Series roller bearings all parts have been eliminated except the anti-friction essentials of load carrying rollers and contacting races. Loose or welded in retaining rings and cages ordinarily found in roller bearings of this type have been discarded in the exclusive MULTIROL design.



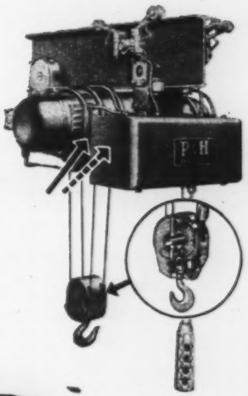
Here rollers are retained by rolled over lips on end shoulders that are solid extended sections of the outer race. Cages are not required and other delicate parts that may wear, warp or break loose in mounting or in service are not needed. Numerous other advantages accrue from this MULTIROL bearing construction in addition to reduced internal wear and longer bearing life.

Lubrication Advantages

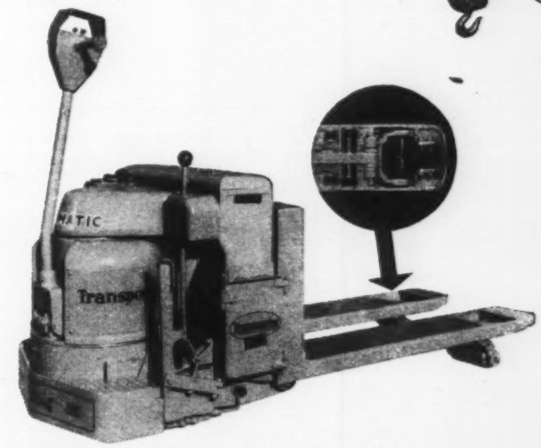


Important among these is the extra protection against destructive foreign particles provided in SE series bearings by a lubricant retaining groove, built into the inside diameter surface of the roller retaining end shoulder. The ring of lubricant held in this groove acts against the inner ring O. D., increasing the sealing effect of the precision tolerances between these shoulders and the inner race. Notice, too, the groove above the roller ends. Acting as a lubricant reservoir, this groove provides MULTIROL SE series bearings with an extra margin of protection against neglected or delayed lubrication.

Typical Performance

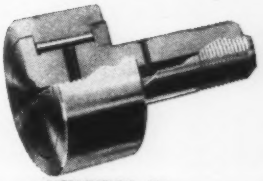


Harnishfeger P&H Hevi-Lift electric hoists carry up to 15,000 pound loads on MULTIROL SE series bearings. Their extra capacity and precision with ruggedness help reduce necessary radial bearing space in the upper and twin bottom sheaves. Two additional SE bearings add smooth efficient and dependable performance in the hoist transmissions.

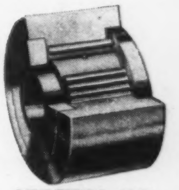


The Automatic Transportation Company's Transporter uses eight Multirol SE Series bearings in the four rear wheels to carry 6000 pound capacity loads easily and freely. Wheels are mounted dual on each fork and two bearings with a center spacer support each wheel. These small but rugged bearings accommodate a large shaft with a comparatively small O. D. and materially reduce starting and rolling friction for finger-tip maneuverability of this heavy duty material handler.

Other McGILL® Bearings



MULTIROL CF



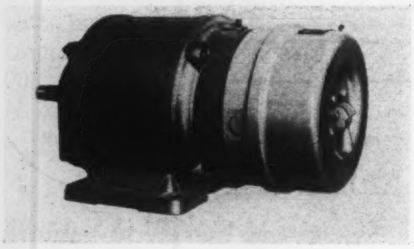
MULTIROL CYR

GUIDEROL CT

A new 140-page Bearing Reference Guide complete with 30 pages of vital engineering data has just been released by the McGill Manufacturing Company. It has the full story on the advantages of Multirol SE Bearings as well as information on the Multirol CF and CYR and Guiderol Bearings. Send now for your copy of McGill Catalog No. 52.

McGILL® — Precision Bearings

McGILL MANUFACTURING COMPANY, INC.
200 N. Lafayette Street, Valparaiso, Indiana

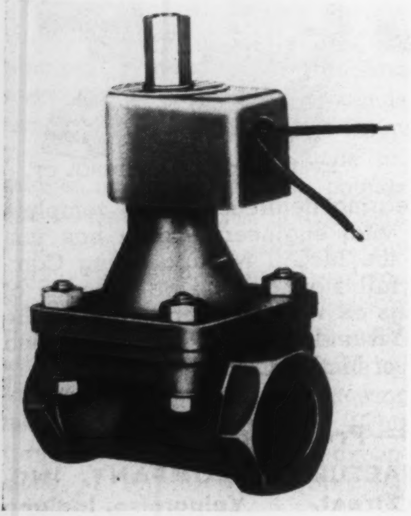


tors. Torque ratings are 1½, 3 and 5 lb-ft. Brakes self-adjust for wear, but critical adjustment of torque can be made for precisely timed stops. Units have thermal ratings of 6, 7 and 8 hp seconds per minute, respectively. All brakes have hand release and mount without dismantling. Motor and brakes are connected in parallel, with starting of motor energizing a magnet to release pressure on rotating friction disks. Motors stop instantly and hold the load. Made by **Dings Brakes, Inc.,** 4740 W. Electric Ave., Milwaukee 46, Wis.

For more data circle MD-18, Page 219

Pilot Controlled Valve

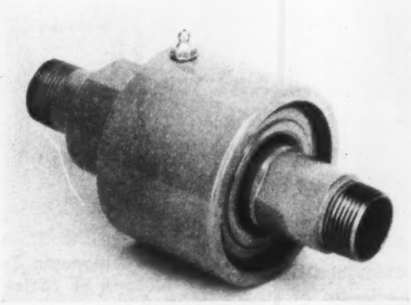
Compact in design, this pilot-operated valve with Saunder's type valve body is intended for use in handling highly corrosive liquids and gases and food products, particularly those containing solid particles. Absolutely tight shut-off is provided. Flexible diaphragm and solenoid core are the only two moving parts. Valve bodies are cast iron, bronze or stainless steel, with a sanitary body and rubber or glass linings available for handling food products. Pipe sizes range from ½ to 2 in., and standard operating voltages are 115-230 v ac, 50-60 cycles, and 115 v dc. Maximum temperature is 180 deg F; maximum pressure is 125 psi. Various special enclosures and class H high-temperature coils are available for maximum pressure of 150 psi. Made by **Automatic Switch Co.,** 391 Lakeside Ave., Orange, N. J.



For more data circle MD-19, Page 219

Rotary Joint

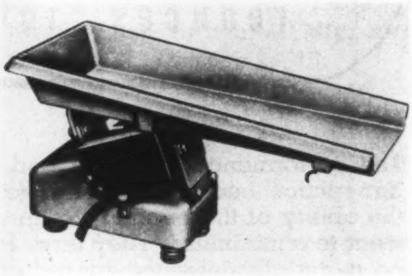
Built for long periods of continuous operation, this rotary joint will convey steam under pressures up to 350 psi and liquids to 3500 psi, at high rotating speeds. Units have single or double-race ball bearings and self-adjusting wear takeup. Self-lubricating rotary seal and mating part are not affected by any misalignment or eccentricity up to 10 degrees. Auxiliary seal prevents loss of grease or condensate past bearing. It withstands temperatures from −100 to 600F. Joint is self-supporting and can be used with or without syphon. It is available in all pipe sizes from ¼ up to 5 in. and can be supplied to withstand corrosive chemicals. Made by **Anco Inc.,** Dept. 28, One Baker St., Providence, R. I.



For more data circle MD-20, Page 219

Vibratory Feeder

Maximum capacity of the Model F-01 electromagnetic vibratory feeder is 2 tons per hour. Designed to feed low tonnage bulk material, it has no rotating parts; all action is confined to inexpensive, easily replaceable leaf springs. Flow rate is controlled by a rheostat in the control box furnished with the feeder. Power consumption is 80 w and operation is from 110 v 60 cycle ac. Baseplate is 5 by 9¾ in.; overall height is approximately 12 in., and weight is 48 lb. Feed pans are available in flat, half-round, Vee and tubular shapes. Made by **Syntron Co.,** Box 220, Homer City, Pa.

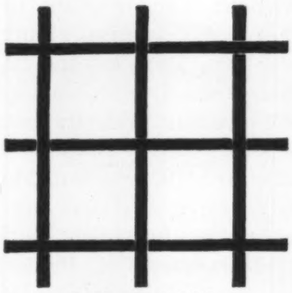


For more data circle MD-21, Page 219

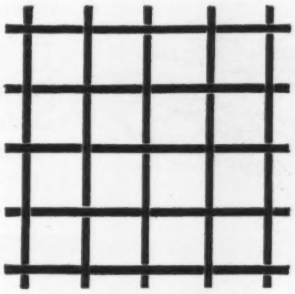
Elapsed Time Indicator

Elapsed Time Indicator
Meeting standard 2½-in. JAN dimensional specification for panel mounting, model HM2ET elapsed time indicator is easy to read, since it has a standard size counter. Unit is hermetically sealed and tamper-proof, as well as being immune to environmental conditions of humidity, temperature and dangerous atmospheres. Motor will start and operate continuous at temperatures ranging from −55 to 85 deg C. Indicator registers in 1/10-hr steps to 9999.9 or hour steps to 99999. Operation is on either 110-125 v or

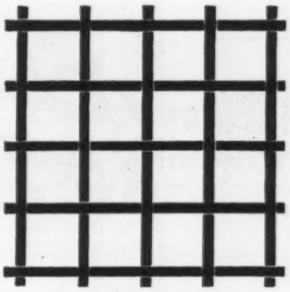
HM2-ET
120 VOLTS 60 CYCLES
TOTAL HOURS
00000



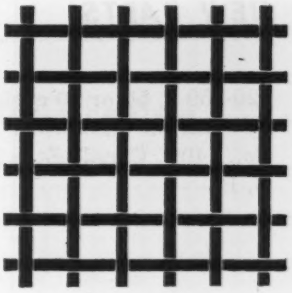
2 Mesh .063″
76.4% Open Area



3 Mesh .041″
76.7% Open Area

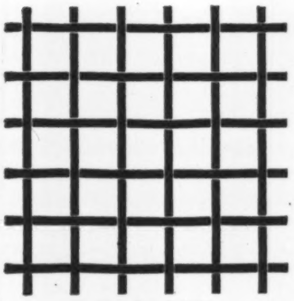


3 Mesh .054″
70.1% Open Area

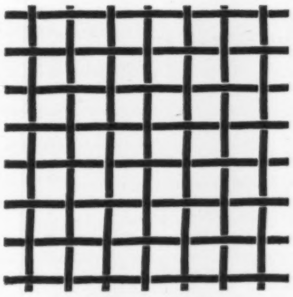


4 Mesh .063″
56.0% Open Area

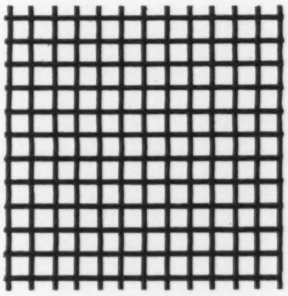
CALL CHASE



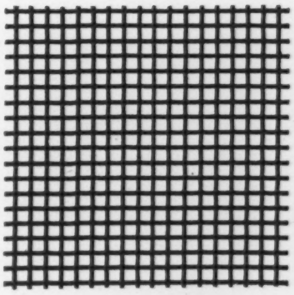
4 Mesh .047″
65.9% Open Area



5 Mesh .041″
63.2% Open Area

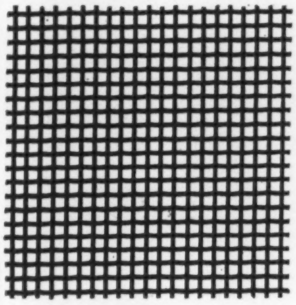


8 Mesh .028″
60.2% Open Area

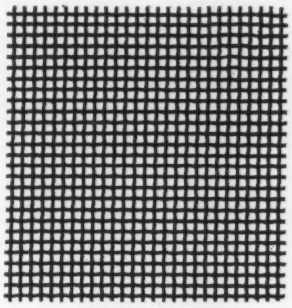


12 Mesh .023″
51.8% Open Area

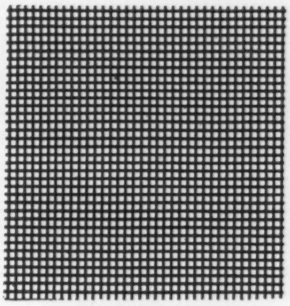
FOR INDUSTRIAL WIRE CLOTH



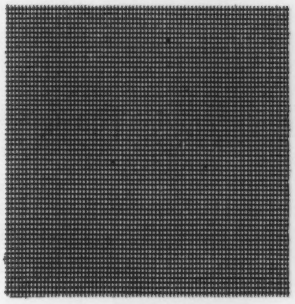
14 Mesh .020″
51.0% Open Area



18 Mesh .017″
48.3% Open Area



24 Mesh .0135″
45.8% Open Area



50 x 40 Mesh .009″
35.7% Open Area

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From coarse wire cloth for window or door grilles . . . right down to extra-fine mesh for food preparation, call Chase.

Double crimped wires of Chase Wire Cloth keep openings square and true . . . mesh uniform. It is woven in a mill which specializes in weaving brass, copper and copper-alloy wire cloth. The result is *quality*.

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Seattle
Waterbury
(†sales office only)

220-250 v, 50 or 60 cycles ac. Made by **Marion Electrical Instrument Co.**, 400 Canal St., Manchester, N. H.

For more data circle MD-22, Page 219

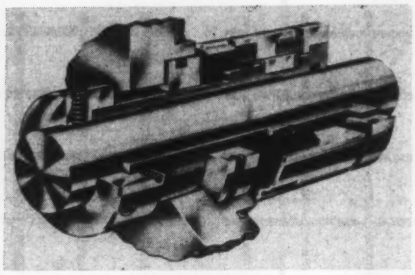
Industrial Clutch

Fully ventilated rigid type clutch is designed for heavy duty service with high starting loads and sustained slippage and is not adversely affected by generated operating heat. Expanding operating tube can be replaced without removing clutch from shaft, and is completely isolated from the heat-generating friction surface. Riveted friction lining is replaceable. Unit is made in 12 in. to 42 in. drum diameters with torque capacities from 27,000 lb-in. to 380,000 lb-in. by **Federal Fawick Corp.**, Fawick Airflex Div., 9900 Clinton Rd., Cleveland 11, O.

For more data circle MD-23, Page 219

Mechanical Seal

Packaged type 8-B heavy duty mechanical shaft seal is designed to withstand pressures up to 1000 psi. When used with split-case pumps, it is not necessary to lift the upper half of the casing to install or remove the seal. Compact design adapts it for use in conventional pump stuffing boxes. It makes use of a rotating sealing washer and "floating" stationary seat. Balance is accomplished by lowering the washer face to a point where stuffing box pressure is not exerted against the sealing area. Made by **Crane Packing Co.**, Dept. M-1, 1800 W. Cuyler Ave., Chicago 13, Ill.



For more data circle MD-24, Page 219

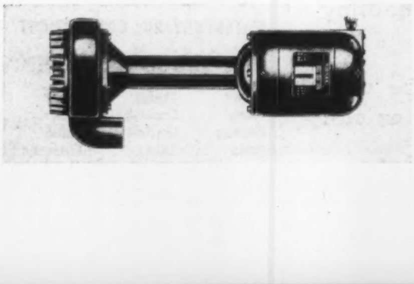
Plastic Sheets

These glass-fiber reinforced polyester sheets, having excellent dimensional stability, resist attack by a wide variety of corrosive chemicals. High arc resistance and low power factor permit their use in electrical applications. Available in sizes to 4½ by 8½ ft in a variety of thicknesses and made in two grades: Grade 1—20,000 psi; Grade 2—40,000 psi. Material can be molded to special shapes with low cost tooling. **Strick Co.**, Plastics Div., Whitaker & Godfrey Aves., Philadelphia 24, Pa.

For more data circle MD-25, Page 219

Centrifugal Pumps

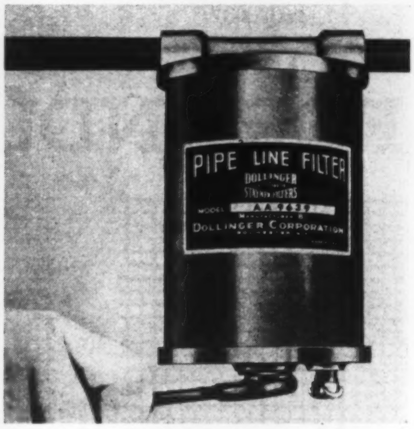
Practical for all types of liquids not too viscous or too corrosive for modern corrosion resistant alloys, models VBH, VD and VE centrifugal pumps are available in 1/20 to 5 hp sizes in variety of port styles and mounting brackets. Larger sizes are rated up to 148 gpm free flow and 9 gpm at 124.7-ft head. Separate intake bracket and support column permits removal of motor and column for maintenance without disconnecting intake bracket and discharge piping. All are seal-less. Double vane impeller is balanced. Internal design assures self-cleaning and prevents clogging when handling liquids with high abrasive or solids content. Motors of any required electrical characteristics can be provided. Made by **Detroit Harvester Co.**, Pioneer Pump Div., 19661 John R St., Detroit 3, Mich.



For more data circle MD-26, Page 219

Pipe-Line Filters

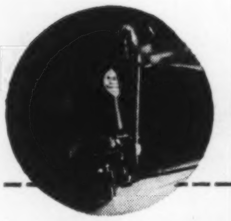
One-bolt accessibility for quick inspection and cleaning without removing from the line is a feature of four new small pipe-line filters. They are designed for installations requiring only 40 psi maximum pressures for compressed air or gas. Two sizes can use either absorption pad media for removal of oil and water vapor or radial fin inserts for removal of dirt and scale. Smaller size filter is 3½ in. diameter and 6½ in. long, while large size has same diameter and a 10-in. length with more filtration surface. Made by **Dollinger Corp.**, 11 Centre Park, Rochester 3, N. Y.



For more data circle MD-27, Page 219

Antiseizing Lubricant

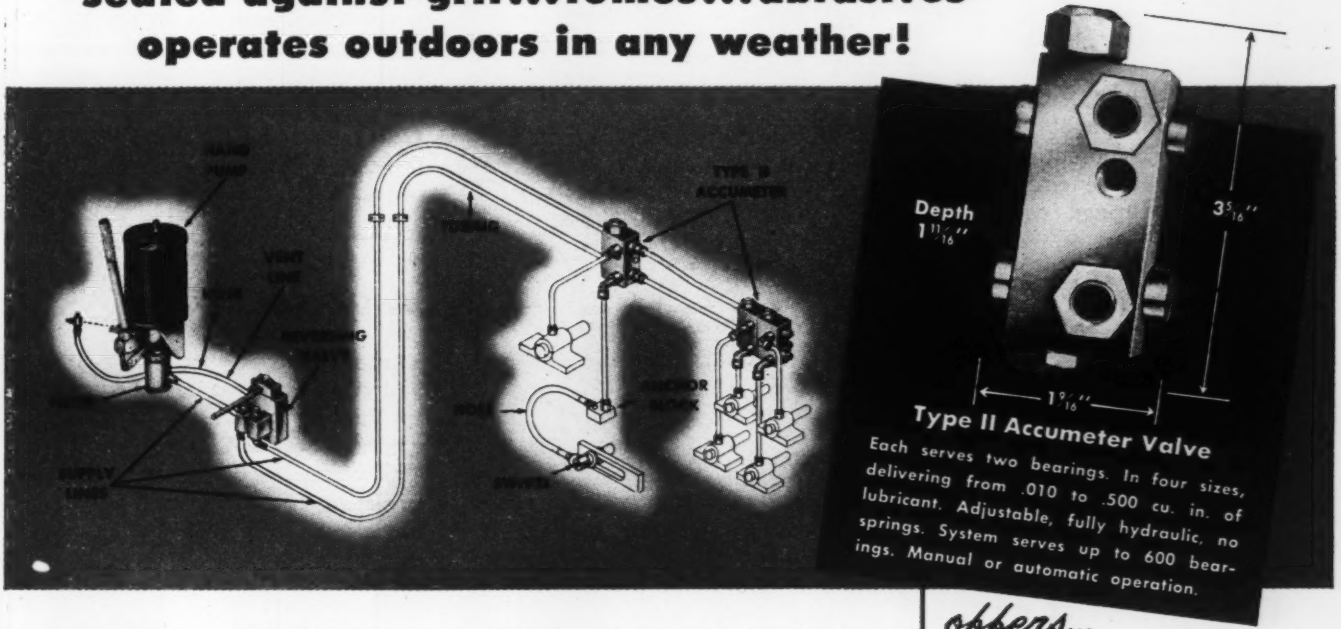
Prevention of seizing and galling at bearing pressures of well over 100,000 psi encountered in machine tools, automatic production machines and other operations, is the function of Molylube Anti-Seize. Product is concentrated molybd-



developed... for "tough-job" lubrication on the largest, heaviest machines...

ALEMITE Accumeter®
CENTRALIZED LUBRICATION

sealed against grit...fumes...abrasives
operates outdoors in any weather!



Type II Accumeter Valve

Each serves two bearings. In four sizes, delivering from .010 to .500 cu. in. of lubricant. Adjustable, fully hydraulic, no springs. System serves up to 600 bearings. Manual or automatic operation.

Alemite Accumeter Lubrication System delivers the exact, measured amount of lubricant to *all* bearings of a machine. In a fraction of the time required for hand lubrication—Accumeter measures and delivers lubricant—*while the machine is in operation!* No down time—no points missed. No wonder 95% of big plants buying machine tools want centralized lubrication!

Type II Accumeter is unmatched for simplicity of design. It's fully sealed and enclosed—yet may be serviced without being removed from machine. Operates in salt spray, severe acid or fume conditions—even totally immersed—because it may be painted or treated with non-corrosives.

Type II Accumeter System can serve single machines or groups—will handle any required lubricant—heavy or light. It is just one of three types of Accumeter Systems made by Alemite. One of them will serve your requirements.

offers...

ALL THESE ADVANTAGES!

- **Eliminates shutdown time for lubrication. *Adds* productive time to machine output.**
- **Seals completely against dirt, grit, water all the way from "Barrel-to-Bearing."**
- **Prevents bearing troubles due to neglect or use of wrong lubricant.**
- **Services *all* bearings—including those inaccessible or dangerous—in one operation.**
- **Avoids work spoilage and bearing repairs due to over-lubrication.**

FACTORY-TESTED . . . FIELD-PROVED

Proved in the field. Exhaustive tests showed *no variation* in the amount of lubricant discharged . . . even after 73,312 lubrication cycles, *equal to 122 years of twice-a-day service.*

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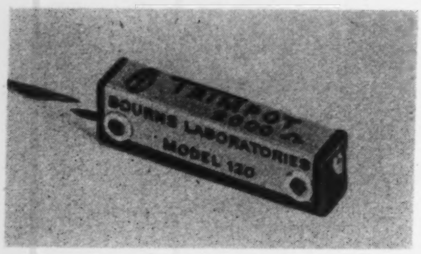
Company ....
City .... State ....

enum disulfide compound which will not melt at temperatures above 600 F. Homogenizing, plus use of synthetic additives makes it possible for lubricant to remain in suspension longer than dry molybdenum disulfide when mixed in machine and cutting oils. Product is available in cartons of 6 or 12 three-ounce tubes, or in 24-oz cans. Made by **Bel-Ray Co.,** Green Village Rd., Madison, N. J.

For more data circle MD-28, Page 219

Small Potentiometer

Measuring only 9/32 x 5/16 x 1¼ in., model 120 Trimpot subminiature wire-wound potentiometer is designed for precise circuit trimming in miniaturized equipment. Units can be mounted individually or in stacked assemblies. Offered in standard resistances of 250 to 10,000 ohms, device is rated ¼-amp. Made by **Bourns Laboratories,** 6135 Magnolia Av., Riverside, Calif.



For more data circle MD-29, Page 219

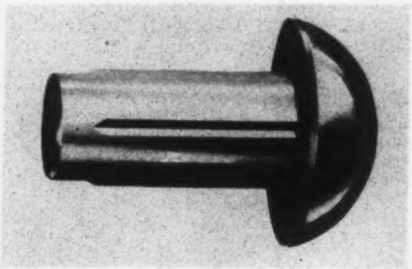
Swivel Nut Elbow Fitting

This one-piece steel elbow with swivel nut for use with ¼ and ⅜-in., aircraft hose is useful in gun charger locations, pilot ejector seat actuators, gas turbine engines and close-quarter airframe locations. Angle turns of 90 and 45-degrees are made in the fitting rather than with the hose. With these fittings, connections can be located close to an obstruction since provision need not be made for swing of angle adapters. Unindexed straight adapters can be used instead. Fittings are available in -4 and -6 sizes in both 45 and 90-degree angles. Made by **Resistoflex Corp.,** Belleville 9, N. J.

For more data circle MD-30, Page 219

Stud Fastener

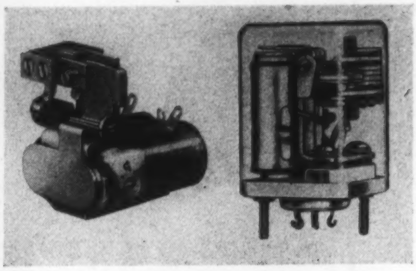
Light metal or plastic name plates, covers and brackets can be attached to heavier structural members by the Driv-Lok stud. Driven by light blows, fasteners are resistant to shock and vibration, yet are easily disassembled without damage to components. Round, flat and countersunk head styles are available in lengths (under head) from ⅛ to ½-in. and shank diameters from 0.067 to 0.250-in. Made by **Driv-Lok Pin Co.,** 715 Chauncey St., Sycamore, Ill.



For more data circle MD-31, Page 219

Sensitive Relays

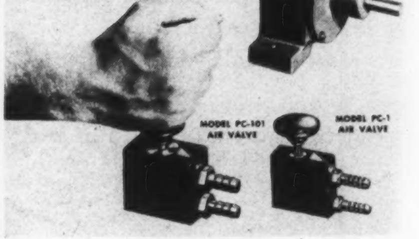
A new group of precision-built super-sensitive relays, designated as the SS series, operate on 10 milliwatts or less with 10 g vibration resistance. Developed for aircraft equipment, these relays are available in open ($1\frac{11}{16}$ by $1\frac{5}{16}$ by $1\frac{11}{16}$ in. high) and hermetically sealed (1½ by 1½ by $2\frac{1}{16}$ in. high) types. Both units are equipped with one form C (SPDT), pure silver contact combinations rated at 2 amp, 28 v dc, or 115 v ac, noninductive load. Balanced armature, set on needlepoint bearings, is virtually friction-free in its movement. Beryllium copper torsion spring maintains stable performance over a wide operating temperature range. Relays are equipped with series-connected coils and available with up to 60,000 ohms of resistance and maximum sensitivity of one to two milliwatts. Windings are varnish-impregnated for protection against moisture on the open relays. Manufactured by **Potter and Brumfield,** Princeton, Ind.



For more data circle MD-32, Page 219

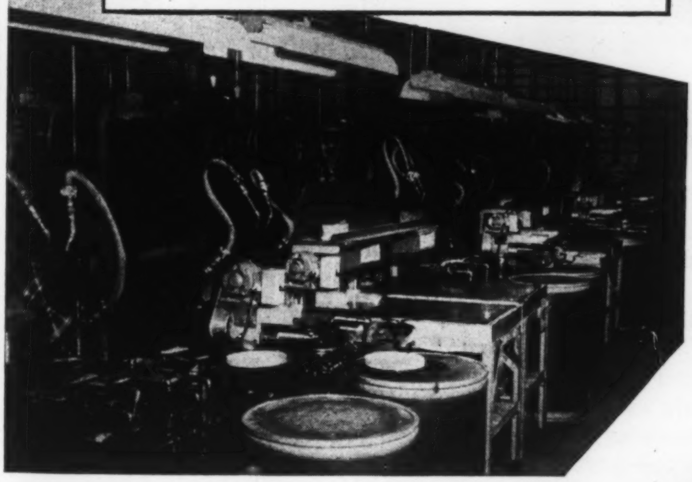
Air Cylinders & Valves

Three spring-return air cylinders and two air valves have been added to line of Mead air-operated devices. Model H-71 air cylinder has a power factor of seven times line pressure, 1-in. stroke and 3-in. bore. Models H-72 and H-73 have the same power factors and 2-in. stroke, 3-in. bore, and 3-in. stroke, 3-in. bore, respectively. First of two air valves is model PC-101 with palm or fist-operated button mounted on the valve plunger. It has 5/16-in. openings and hose nipples



The U. S. Rubber hose that breaks records... and helps make 'em!

U. S. Matchless Steam Hose installed on hydraulic record press.



Battery of presses in the record factory. Note high flexibility of the hose.

Carrying steam at 350°F, 120 pounds pressure, and flexing 6 times a minute—that's the record-breaking job U. S. Matchless® Hose does in making phonograph records for an Eastern factory. Installed on hydraulic presses, Matchless has been on the job *for over two years* so far, with *no* failures. No ordinary hose could stand up under this treatment or protect the worker from dangerous steam. This United States Rubber Company hose really pays off in durability and safety.

Naturally, like every "U. S." product, Matchless Hose is the result of careful study and manufacturing control on the part of "U. S." engineers. For any industrial problem, call on these engineers at any of our 25 District Sales Offices. Or write to address below.

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MECHANICAL GOODS DIVISION • ROCKEFELLER CENTER, NEW YORK 20, N. Y.

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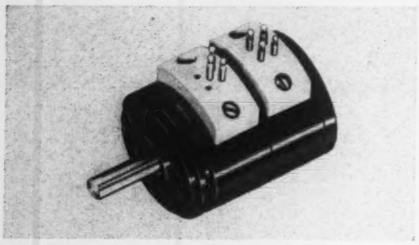
for ⅜-in. ID hose. Model PC-1 air valve has nipples for ¼-in. ID hose and is recommended for cylinders up to 3-in. bore; for larger cylinders use model PC-101. Made by **Mead Specialties Co.**, Dept. CV-25, 4114 N. Knox Ave., Chicago 41, Ill.

For more data circle MD-33, Page 219

Gang Potentiometer

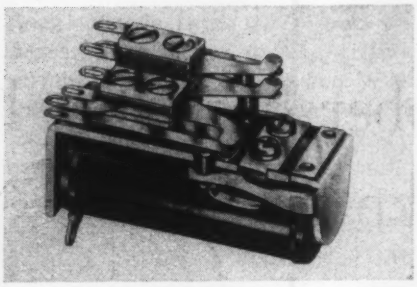
From one to six section assemblies are available in this 1⅛-in. diameter potentiometer which requires a 0.6 oz-in. operating torque for a six-section unit. Assembly is made without external clamps or bolts, and a solid stainless steel shaft is used to couple the movable arms of each section. Mechanical shaft rotation is 360 degrees continuous. Resistances from 500 to 70,000 ohms per section are available, and each section can dissipate 2 w at 25 C. Linearity tolerance is ±0.5 per cent for each section. Nonlinear outputs can be obtained. One to ten-turn 5 w units are also available in 1¾-in. diameter single units. Made by **G. M. Giannini & Co. Inc.**, 117 E. Colorado St., P. O. Box N, Pasadena, 1, Calif.



For more data circle MD-34, Page 219

Fast-Action Relay

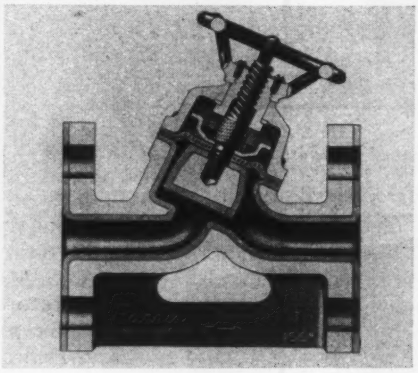
Long core design of fast-action T-J telephone-type relay makes it suitable for complex circuits involving pull-in and drop-out time delay. Engineered to specifications, it is available with coils for all standard voltages up to 110 v dc and contact combinations up to four-pole, double-throw, or six-pole, single-throw. Standard fine silver contacts are rated at 150 w, 3 amp maximum noninductive load. Palladium or other contact materials can be supplied. Relay is insulated to withstand 1000 v ac, and metal parts are heavily plated to resist corrosion. Available with varnish impregnation; hermetic sealing is offered to meet military specifications. Made by **Comar Electric Co.**, 3349 W. Addison St., Chicago 18, Ill.



For more data circle MD-35, Page 219

Diaphragm Valves

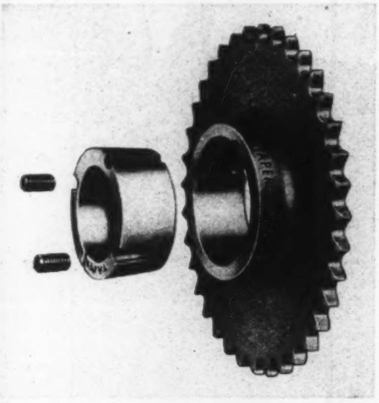
Shutoff, throttling and control of acids, chemicals and other corrosive and abrasive fluids are functions of X-V series diaphragm valves, which feature individual operation of diaphragm and disk. Sealing the mechanism and seating the disk are thus accomplished separately, minimizing wear on the diaphragm. Disk is constructed with ample covering surface material for airtight closure over fine grit. Other features include replaceable disk, full port capacity, easy-to-read valve position indicator, low pressure drop, and rib support for body strength. Made with bodies of cast iron, 316 stainless steel or Hastelloy C, valves can be either unlined or lined with same material as diaphragm and disk. Diaphragms can be rubber, Neoprene, Kel-F or Buna N. Connections are flanged, screwed or union. Motor-operated units are also available. Made by **Farris Flexible Valve Corp.**, 702 Commercial Ave., Palisades Park, N. J.



For more data circle MD-36, Page 219

Sprockets & Roller Chain

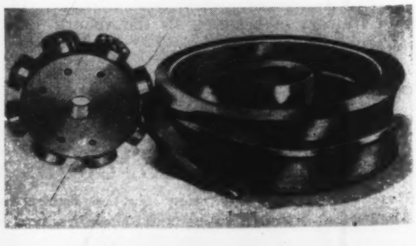
Chain drives, now incorporating the Taper-Lock principle, are available as "off the shelf" items. Wide range of sizes offered eliminates need for reboring sprockets to fit shafts and regrinding or turning of shafts to get a tight fit. Bore sizes range from ½ to 3 in. in 1/16-in. increments in eight bushing sizes. Sprockets have no flange or protruding parts. Pitch range of B-type steel sprockets is 40 to 100. Chain is packaged in 10-foot lengths or can be furnished in 50 or 100-foot reels. Made by **Dodge Mfg. Corp.**, Mishawaka, Ind.



For more data circle MD-37, Page 219

Roller Gear Drive

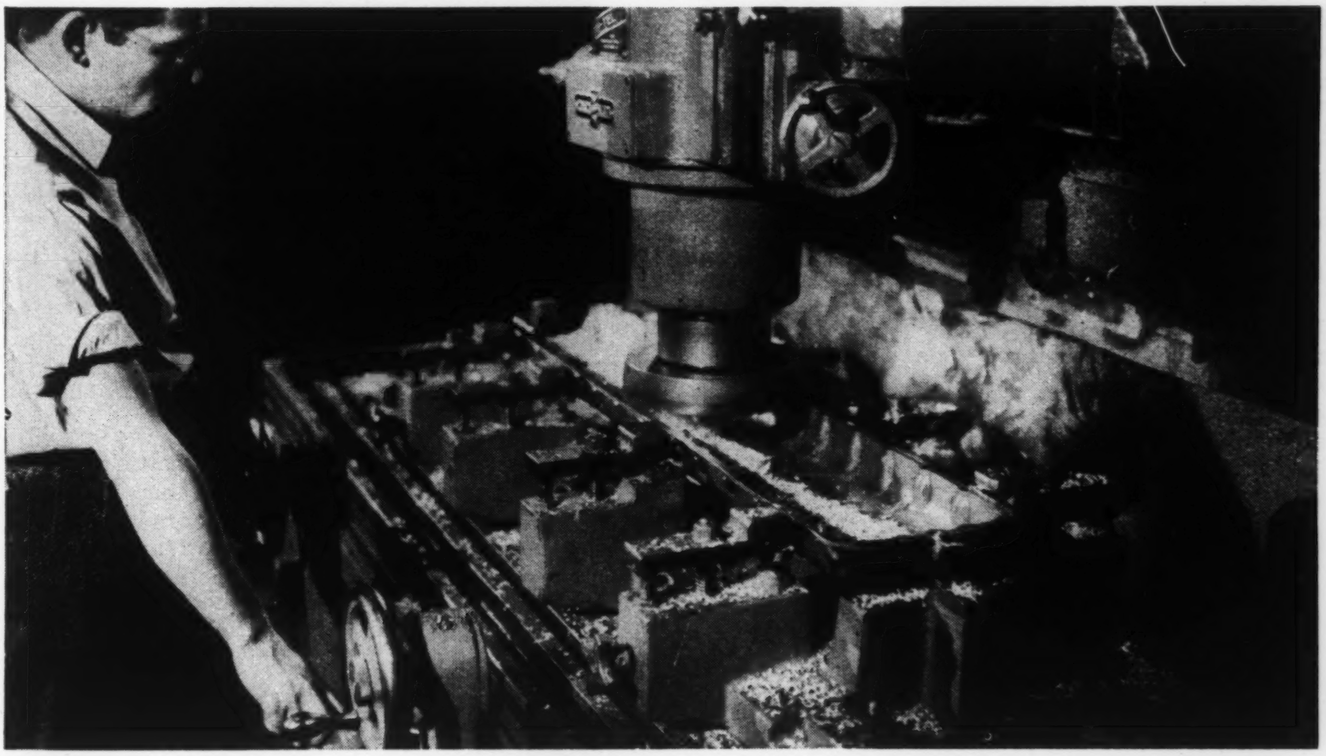
Standardized roller gear drives, intermittent motion or indexing mechanisms which replace Geneva drives, ratchet and crank mechanisms are now available for use in



Dow

MAGNESIUM OFFERS YOU SUPERIOR MACHINABILITY

Increased tool life and lower machining costs are possible



Of all structural metals, magnesium is the easiest to machine. Heavier depths of cut and higher rates of feed than are used on other metals are possible when machining magnesium.

With increased machining speeds, magnesium helps you realize savings in production costs, particularly when extensive machining operations are required.

Magnesium cuts freely, too, assuring increased tool life. In fact, the life of high-speed steel cutting tools when machining wrought magnesium equals the life of carbide-tipped tools on other metals.

Excellent surface finish is obtainable when machining magnesium because there is no tendency for metal to tear or drag. Extremely accurate parts with dimensional tolerances of only a few ten thousandths of an inch can be made by standard machining operations.

Free Book: "MACHINING MAGNESIUM". This fact-filled book will give you complete data on all machining operations with magnesium. It also includes information on tool design, coolants and shop practice. For your copy, call your nearest Dow sales office or write THE DOW CHEMICAL COMPANY, *Magnesium Department*, Midland, Michigan.

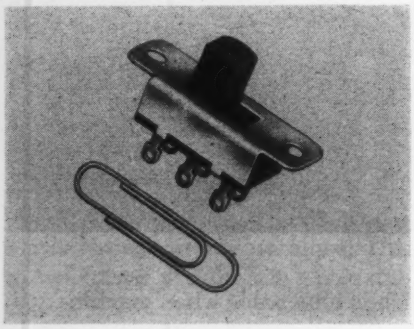
you can depend on DOW MAGNESIUM Dow

indexing dials, carriers, conveyors and similar equipment. Drives are made with 6, 8, 10, and 12 stops per revolution of output shaft and with indexing times of either ¼, ⅓, ½ or ¾ of total cycle time. They have been used on dial and roll feeds, carrier chains and conveyors at speeds up to 800 pieces per minute. Early custom-made units reportedly operated without maintenance for 8000 hours in cases where extreme precision was required and up to 20,000 hours where precision was not a factor. Made by **Ferguson Machine & Tool Co.,** P. O. Box 191, Ferguson Sta., St. Louis 21, Mo.

For more data circle MD-38, Page 219

Miniature Slide Switch

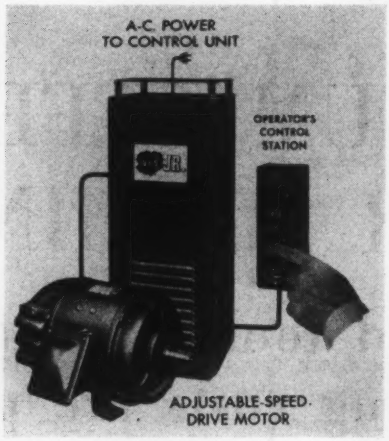
Rated 0.5-amp at 125 v, this miniature double-pole double-throw slide switch combines snap action with compactness for appliance, instrument and small equipment control. It measures 1⅜ in. long by $\frac{17}{32}$-in. wide by $\frac{11}{32}$-in. deep. Laminate Bakelite base minimizes arc tracking. Two types are available, with and without Underwriters' Laboratories approval. Made by **Stackpole Carbon Co.,** St. Marys, Pa.



For more data circle MD-39, Page 219

Adjustable Speed Drive

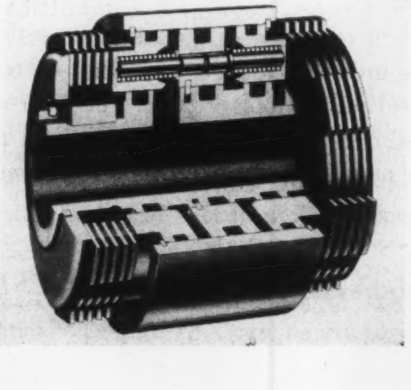
An electronic-type adjustable-speed electric motor drive, the V-S Junior is designed for relatively low power requirements from ¾ to 3 hp. The stepless speed-changing unit operates at speeds from 270 to 2300 rpm. Speeds as low as 75 rpm can be used for setting-up operations, light loads or intermittent duty. Components of system are drive motor, operator's control station and ac powered electronic control unit. Control station is housed in NEMA No. 1 enclosure. Electronic control cabinet unit is 30½ in. high, 12 in. wide, 10⅝ in. deep and weighs 75 lb. Optional equipment available includes foot-operated control stations, gearmotors, and speed indicators. Manufactured by **Reliance Electric & Engineering Co.,** Cleveland 10, O.


A-C POWER TO CONTROL UNIT
V·S JR.
OPERATOR'S CONTROL STATION
ADJUSTABLE-SPEED DRIVE MOTOR

For more data circle MD-40, Page 219

Multiple Plate Clutch

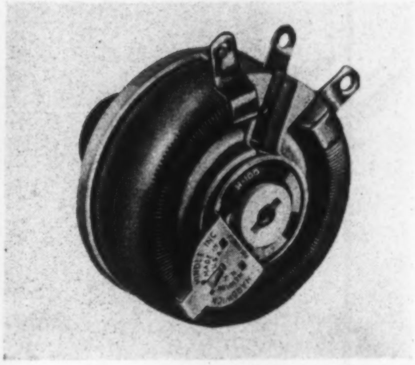
A new standardized multiple-plate clutch incorporates an integral oil cylinder to clamp the plate stack. Model MOS (single) and MOD (duplex) are designed to provide constant torque capacity with compactness and adaptability to remote control. Extensive use of snap rings is employed to provide easy disassembly. No adjustment is required to compensate for friction-plate wear, since the pressure plate is the ram of the cylinder, whose travel increases automatically as the plate stack wears. Made by **Twin Disc Clutch Co.,** Racine, Wis.



For more data circle MD-41, Page 219

High-Wattage Rheostats

H-type Hardwick Hindle rheostats provide high-wattage variable control of electric power. Designed to comply with current standards of JAN military specifications, RTMA, NEMA, and listed by Underwriters Inc., these units are available in 50, 75, 100, and 150 watt-sizes with 0-0.5 to 0-10,000 ohm resistance ranges. All models are bonded with high temperature enamel. Made by **Hardwick Hindle Inc.,** Newark 5, N. J.



For more data circle MD-42, Page 219

Centrifugal Pumps

Available in ⅓, ½, ¾ and 1-horsepower sizes, the Centri-thrift line of centrifugal pumps can be used with air-conditioning and laundry equipment, and for hot and cold water circulation, booster service, cooling systems, and other types of liquid transfer including use as a coolant pump by machine tool manufacturers. Pumps are available in either motor-mounted or belt driven models. Powered by 3450 rpm capacitor-type motors with built-in overload protection, the pumps will develop heads up to 92 feet with capacities up to 50 gpm. Features are corrosion-resistant stainless steel pump shafts, removable bronze wearing rings and rotary seals which eliminate "packing-box drip." Bronze impel-

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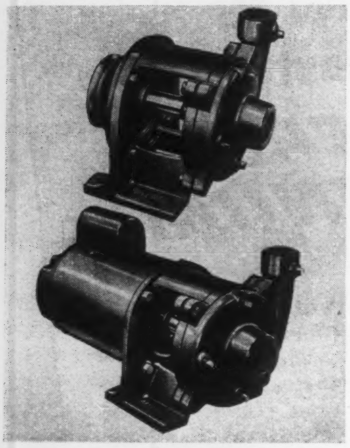


lers are dynamically balanced. All parts are easy to replace. Made by **F. E. Meyers & Bros. Co.,** 904 South Orange St., Ashland, O.

For more data circle MD-43, Page 219

Long Stroke Diaphragms

Bellofram is a generic term coined by Kendall to denote their long-stroke, deep-convolution, constant-area diaphragms. Designed to operate through pressure ranges from $\frac{1}{4}$-in. water to 500 psig. Made with a fabric insert to furnish strength while an elastomer acts as a seal. Nylon fabric is used where operating temperatures do not exceed 210 F, and Orlon is used up to 260 F. Glass cloth is used for temperatures up to the limits of the Silastic elastomer, which is 500 F for sustained operation and 600 F for short exposures. Developed by **Kendall Controls Corp.,** Bellofram Div., 144 Moody St., Waltham 54, Mass.

For more data circle MD-44, Page 219

High-Temperature Lubricant

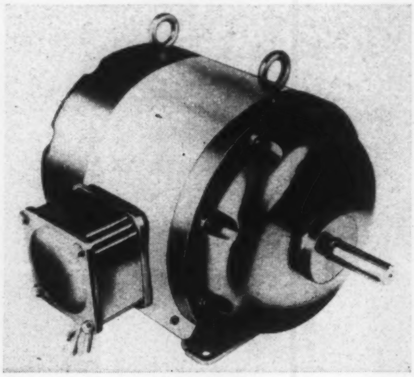
Molykote M-30 lubricant, a dispersion of near-colloidal particles of Molykote powder in a polyalkylene glycol vehicle is particularly useful in high temperature applications. The success of Molykote M-30 as a high-temperature lubricant is attributed to the fact that the polyalkylene glycol vehicle allows the Molykote particles to be carried into the innermost recesses of the parts being lubricated. The vehicle dissipates under heat and leaves a smooth, tenacious film of Molykote to provide lubrication. Applied by brush, oil can or automatic lubricator; however, agitator-type automatic lubricators should be employed since there is a slight settling in this dispersion. Flash point is in excess of 500 F, and carbon residue is less than 0.1 per cent. Made by **The Alpha Corp.,** 179 Hamilton Ave., Greenwich, Conn.

For more data circle MD-45, Page 219

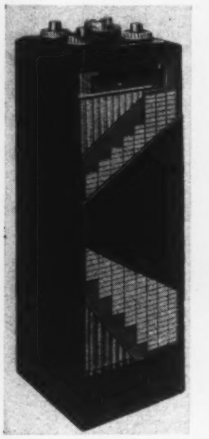
Chemical Plant Motors

Line of chemical plant motors in ratings from 1 to 40 hp and in NEMA frames up to 405 are now available in totally-enclosed and UL-approved explosion-proof construction. Electrical performance is same as standard line of totally-enclosed, fan-cooled or explosion-proof motors. Class A chemical insulation treatments allow use of motors in applications involving acids, alkalies, peroxide dyeing and bleaching, canning and packing. Cast bronze, aluminum or cast iron ventilating fans, and cast bronze, cast iron, stainless, or flattened expanded-metal ventilating grilles may be specified. Automatic drain-and-breather plugs, as well as stainless shafts are available. All frames have stainless-steel outer shells. Steel parts are protected by corrosion-resistant coating and paint, and die-cast rotor is sprayed with inhibitor. Repellent grease at shaft extension hub keeps moisture away from double-row, prelubricated sealed bearings. Manufactured by **Robbins & Myers Inc.,** Industrial Motor Div., Springfield 99, O.

For more data circle MD-46, Page 219



Industrial Storage Battery

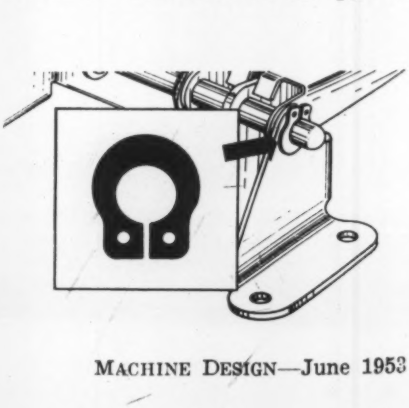


Twenty per cent more capacity in the same space is the advantage claimed for the line of T-H Exide Ironclad batteries designed for materials handling and haulage jobs. Polyethylene nonoxidizing slotted plastic tubes keep the active material in constant contact with grid spines and permit free electrolyte penetrations throughout the active material. Grids contain corrosion-resistant Silvium—a lead-silver alloy. Jar is made of seamless rubber. Named T-H for "Thrifty Hauler", battery is available from **Electric Storage Battery Co.,** Philadelphia 2, Pa.

For more data circle MD-47, Page 219

Grip Rings

Designated as the Truarc series 5555, this fastener provides an effective locking collar on small shafts. Grip ring makes a positive shoulder which is secure against thrust and vibration. Made of carbon spring-steel, rings are applied or removed from a straight ungrooved shaft with Truarc pliers. Fit shaft diameters of $\frac{1}{8}$, $\frac{3}{16}$, $\frac{1}{4}$,



Is compact design your problem?

here's how portable electric tool manufacturers solve it with **NEEDLE BEARINGS**

Torrington Needle Bearings are designed into many portable electric tools because their small cross section permits the close shaft-center distances so necessary to compactness.

They have been *performance-proved* through years of successful operation on counter shafts, pinion shafts and spindles in drills, buffers, sanders, grinders and other electric tools.

Since it was introduced nearly twenty years ago, many manufacturers throughout industry have made the Torrington Needle Bearing "standard equipment" for products requiring an anti-friction bearing that's light, compact and has high rated radial capacity.

Why not find out how Torrington Needle Bearings can be used to advantage in your products?

THE TORRINGTON COMPANY, Torrington, Conn., South Bend 21, Ind.

TORRINGTON *NEEDLE* BEARINGS

Needle • Spherical Roller • Tapered Roller • Straight Roller • Ball • Needle Rollers

Trade-marks of some of the portable tool companies whose products enjoy the benefits of Needle Bearings.

SKIL PORTABLE TOOLS

STANLEY

MILLERS FALLS TOOLS

SIOUX

PET POWER TOOLS

PORTER CABLE Speedmatic

Thor

Milwaukee

Black & Decker

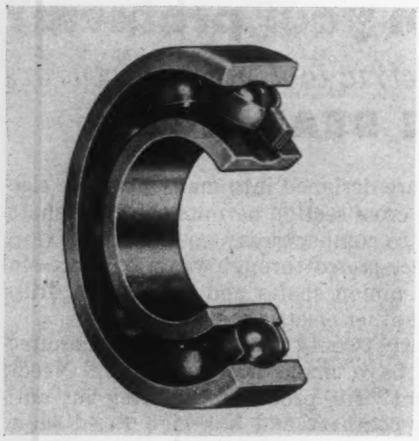
Mall

$\frac{5}{16}$, and $\frac{3}{8}$-in. Made by **Waldes Kohinoor Inc.,** 47-16 Austel Place, Long Island City 1, N. Y.

For more data circle MD-48, Page 219

Radial Ball Bearing

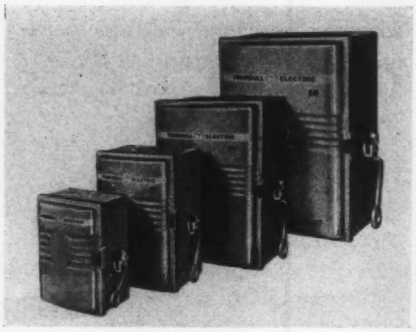
Precision ground radial ball bearings are solid race type with ball retainers. Designated C series, they are for light duty radial, thrust or combined load service at maximum speeds of approximately 5000 rpm. Bores range from $\frac{1}{4}$ to $1\frac{3}{8}$ in. diam in $\frac{1}{8}$-in. increments; OD from $\frac{5}{8}$ to $2\frac{1}{2}$ in. Raceways are ground and polished; balls are chrome alloy. Bearings are available with single or double shields or with no shields. Manufactured by **Nice Ball Bearing Co.,** 30th and Hunting Park Ave., Philadelphia 40, Pa.



For more data circle MD-49, Page 219

Safety Switches

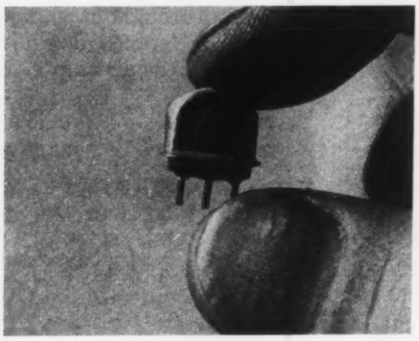
Designed to meet all but the most severe operating demands, standard duty HCI safety switches are available in ratings of 30, 60, 100 and 200 amp; 240 and 600 v; two, three and four poles. Switches incorporate a pole unit which is, in effect, a self-contained switch. Pole unit features arc-quenching action which is similar in principle to arc-extinction features of modern circuit breakers. Switches have quick-make, quick-break action and interlocking covers. They meet NEMA type A standards and are UL approved. Made by **General Electric Co.,** Trumbull Electric Dept., Dept. M-3, 41 Woodford Ave., Plainville, Conn.



For more data circle MD-50, Page 219

Point-Contact Transistors

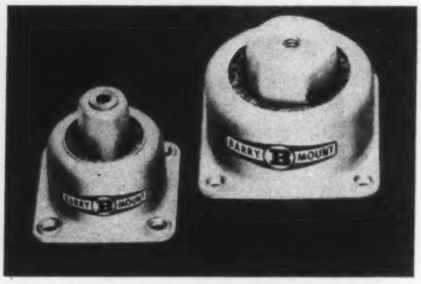
Besides entering into quantity production of point-contact type transistors, this company is offering the services of its electronics laboratory and test equipment. Its personnel is available for consultation in the transistor field. Transistors are made under Bell Telephone Laboratories License by **Hydro-Aire Inc.,** 3000 Winona Ave., Burbank, Calif.



For more data circle MD-51, Page 219

Vibration Isolators

All-Metl vibration isolators, Type 7630 and Type 7640 are specifically designed to eliminate loss of efficiency due to damper packing. These units are respectively JAN cup-type Size 1 and JAN cup-type Size 2. The new units are so designed that a load-bearing spring returns the damper to its normal position on every cycle, thus preventing packing of the wire-mesh vibration-absorbing unit. Additional features of the new units are very light weight, a new hex top to simplify installation, high isolation efficiency, ruggedized construction, and wide temperature tolerance. Made by the **Barry Corp.,** 700 Pleasant St., Watertown 72, Mass.



For more data circle MD-52, Page 219

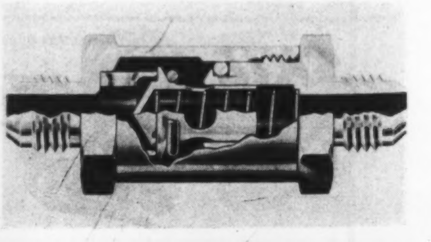
Free-Machining Steel

Designated the J&L 1200 series, a steel for making screws, nuts, studs, bolts, and other small machine products is available in the form of cold-finished bars. Tests and production trials show this steel gives greater uniformity, superior machinability, and a higher quality finish than conventional screw stock. Produced by the open hearth process by **Jones & Laughlin Steel Corp.,** Pittsburgh 30, Pa.

For more data circle MD-53, Page 219

Flow Limiter Valve

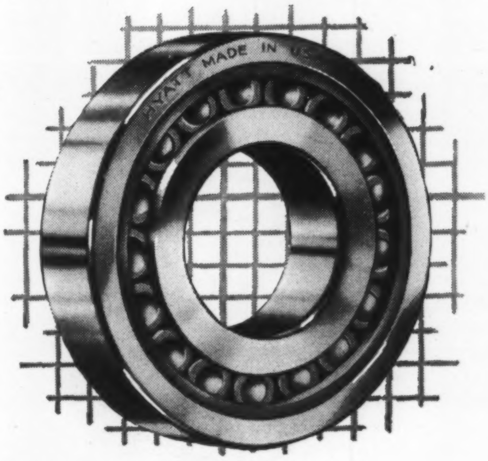
Design of this flow limiter valve allows flow in one direction up to any predetermined rate, but shuts off quickly to prevent higher flows, while allowing unrestricted flow in the opposite direction. Unit serves equally well as an excess flow, automatic drain or dump valve. Ex-



MEMO

Al—
To get greatest load-carrying
capacity in such a limited
space, I'd recommend
cylindrical Roller Bearings—
Hyatts for very best results.
Jim

It's a Matter of BETTER DESIGN!



"Jim" has the right answer. The one best way to handle radial loads is to design with *cylindrical roller bearings!* And if you're looking for the very best operating results, specify *Hyatt* Roller Bearings!

Within given boundary dimensions, you achieve maximum radial load carrying capacity—and longest bearing life—by using radial roller bearings. No load-carrying capacity is sacrificed to provide for other conditions, and more practical design and simplified assembly procedures usually result. And, when you work with *Hyatts,* you have the additional advantage of *greater design flexibility,* because Hyatt offers the most complete line of radial roller bearings available anywhere—with more than 800 bearing sizes in the Hy-Load series alone!

If you aren't already profiting through the use of Hyatts, write for our general catalog, No. 150. It will put the answer to *any* bearing problem at your fingertips. Hyatt Bearings Division, General Motors Corporation, Harrison, N. J.

HYATT ROLLER BEARINGS

act repeatability together with dead-tight closing is achieved. Valves are made with male tube or pipe connections on discharge side in restricted flow direction and with either male or female connections on inlet side. Made by **James-Pond-Clark,** 2181 E. Foothill Blvd., Pasadena 8, Calif.

For more data circle MD-54, Page 219

Gasket Material

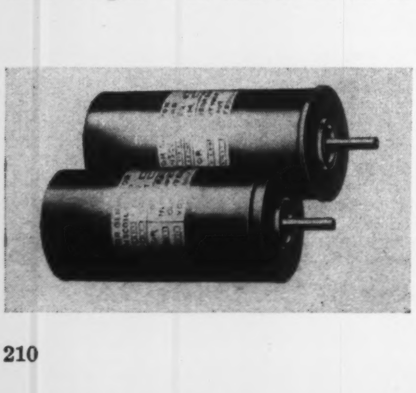
The compressibility of Du Pont neoprene rubber and the heat resistance of asbestos are combined in Asbestoprene gasket material, developed for applications customarily using glue-glycerin treated paper. Product features high dimensional stability, does not cause corrosion of light metals, and is resistant to oils, water, gasoline and antifreeze solutions. Tensile strength is 1500 psi minimum in the machine direction. Mullen burst strength is 130 lb per 1/16-in. gage; compressibility, 20-30 per cent at loading of 1000 psi; and recovery, 40 per cent minimum. A 1/16-in. sheet can be bent around 1/32-in. mandrel without cracking. Developed by **Victor Mfg. & Gasket Co.,** 5750 Roosevelt Rd., Chicago, Ill.

For more data circle MD-55, Page 219

Miniature Motor-Generators

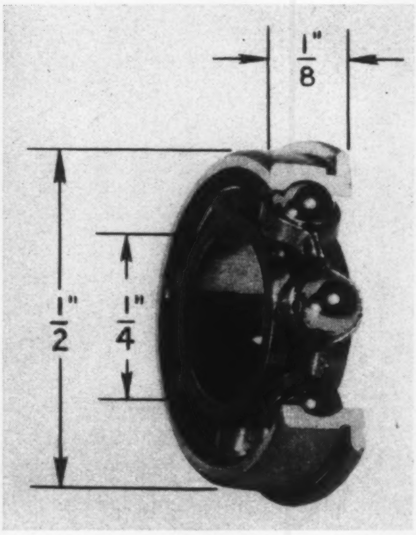
Phase voltage of the motor in this line of miniature control motor-generator and motor-generator gear train combinations for servomechanisms is 26 v with a maximum stall power of 2.6 w per phase. Minimum stall torque is 0.3-in. oz. The 400-cycle motor-generator weighs 4 oz and is 0.9-in. in diameter. Generator output is 0.34-v per 1000 rpm with an excitation power of 2.0 w maximum. Phase shift working into a 100,000 ohm load is 5 degrees, maximum null is 20 mils and maximum swing is 10 mils. Made by **Transicoil Corp.,** 107 Grand St., New York 13, N. Y.

For more data circle MD-56, Page 219



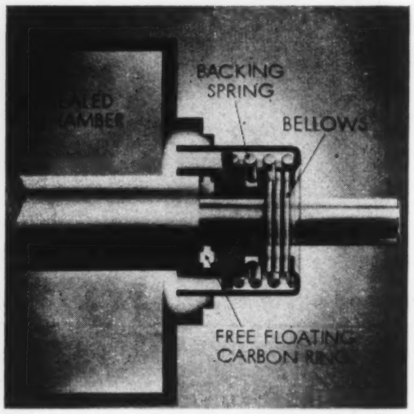
Instrument Bearing

An extra-light, flanged instrument ball bearing, the Micro FR188 features straight rather than tapered OD, refined processing to super-precision (ABEC Class 5 and higher) tolerances, and a two-piece, cone-controlled, cylindrical-pocket, pressed metal cage. The balanced design favors low and uniform running torque as well as quiet operation. Construction is extra-light, with all excess metal eliminated to conserve weight and space. Recommended for gimbals and general precision instrument assemblies. Available in all-stainless steel (type 440) as well as conventional SAE 52100 from **New Hampshire Ball Bearings, Inc.,** Peterborough, N. H.



For more data circle MD-57, Page 219

Bellows Shaft Seal

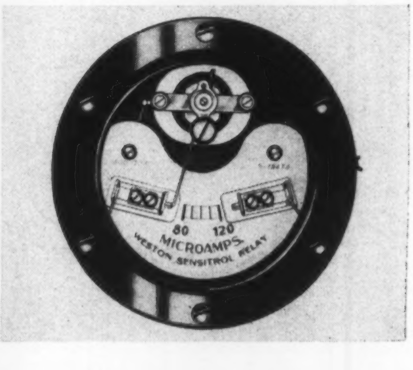


Adaptable to shafts as small as ¼ in., diameter, metallic bellows shaft seal is designed for sealing the control shafts of hermetically sealed equipment, yet permits freedom of the shaft. Because it withstands wide range of temperature changes as well as heat and cold, seal is especially applicable to aircraft components. It is also unaffected by pressure changes. Seals are supplied to specifications and in production quantities by **Clifford Mfg. Co.,** 124 Grove St., Waltham 54, Mass.

For more data circle MD-58, Page 219

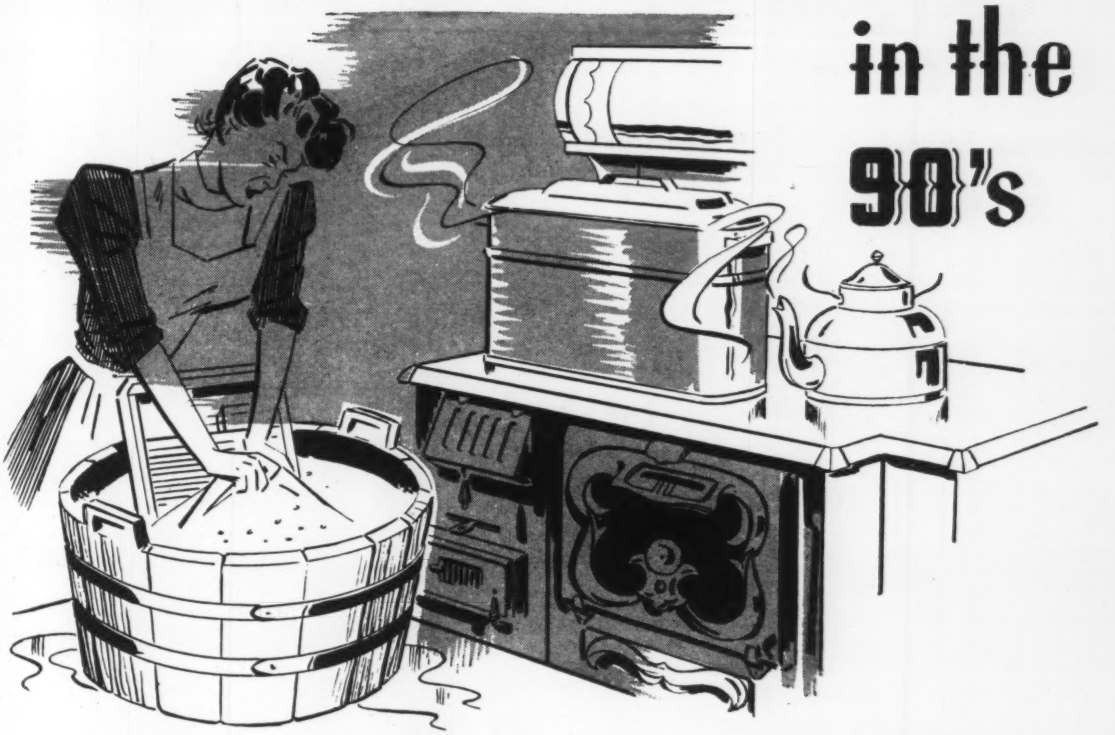
Control Relay

Built-in solenoid release, moisture seal and self-shielded core magnet mechanism are the features of the Sensitrol relay. It is supplied in a variety of ranges with double magnetic contacts, or with single magnetic contacts to make contact on either increasing or decreasing values. Sensitivities as high as 2-0-2 microamperes are available and both ac and dc voltage ranges can be supplied self-contained up to 500 v. Available from **Weston Electrical Instrument Corp.,** Newark 5, N. J.



For more data circle MD-59, Page 219

mondays were really BLUE in the 90's



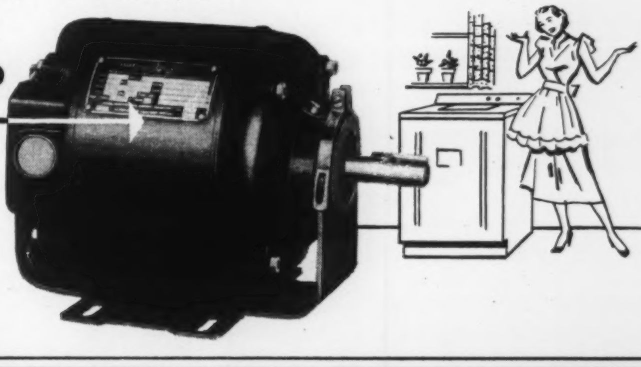
Men folks worked from sun to sun . . . but Mother's work was never done . . . in the 90's. Wash days added to her burden . . . she spent many hours toiling near a hot, kitchen stove.

The electric motor has worked miracles to relieve mankind of time-consuming, laborious tasks and provide for the living standards we enjoy today.

Emerson-Electric is recognized as a leader in producing motors which power a long list of MODERN home appliances. To name just a few: automatic washers, ironers, dryers, refrigerators, freezers, oil burners and stokers.

Founded more than half a century ago, Emerson-Electric builds dependable, efficient motors for use in appliances and equipment for the home, on the farm, in business and in industry. Your inquiry is invited on the complete Emerson-Electric motor line, in horsepower ratings from 1/20 to 5. THE EMERSON ELECTRIC MFG. CO., St. Louis 21, Mo.

MODERN LIVING **IS POWERED WITH ELECTRIC MOTORS**



HERMETIC MOTORS
1/8 to 20 H. P.

We offer manufacturers of hermetically sealed units a broad background of engineering experience in hermetic motor design. We also have unequalled facilities for the production of hermetic motor parts. Cooperative engineering service available without charge. Write for Bulletin No. 427.

EMERSON ELECTRIC
MOTORS • FANS APPLIANCES

LEADERS IN THE FAN AND MOTOR INDUSTRY SINCE 1890

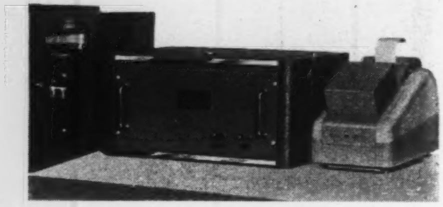
ENGINEERING DEPARTMENT

EQUIPMENT

For additional information on this new equipment, see Page 219

Angular Position Encoder

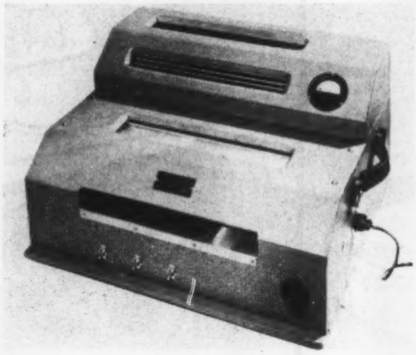
An analog to digital converter, this unit can be used for rapidly indicating angular shaft positions of 360 degrees or less with an accuracy of ±0.1% without the use of gearing. A maximum shaft speed of 100 rpm is presently possible. Model 14310, attached to either Minneapolis-Honeywell, Leeds & Northrop, or Bristol self-balancing potentiometers, records printed data on tape from a Clary printer. Model 14311 is designed to operate standard card-punch equipment. Heart of the equipment is a new coded multisegment commutator which transmits signals to a relay rack. Unit has a maximum readout rate of 3 readings of a 3-decimal digit number per second. This system has application wherever a decimal representation of a shaft position is required. Developed by **G. M. Giannini & Co. Inc.**, 117 E. Colorado St., P. O. Box N, Pasadena 1, Calif.



For more data circle MD-60, Page 219

Dry Photocopy Machine

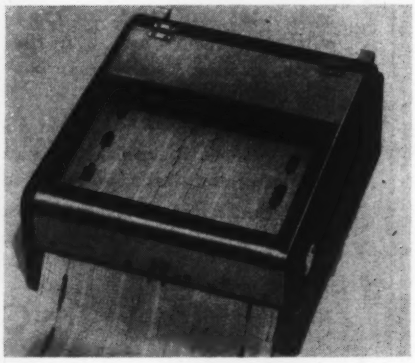
Black and white positive copies of anything typed, written, printed, or drawn can be reproduced in the same size as the original material with the Exact-Photo-Copy machine. Exposures are made in about 8 seconds and copy developed in 15 seconds. Process requires no washing, fixing, or drying. Accommodates copy up to 12 in. wide in any length. Original material is inserted into exposure section with sheet of negative paper and exposed required length of time. Both sheets are removed, then negative and sheet of transfer paper are inserted into processing section until developed. These two sheets are removed and peeled apart, giving finished copy. Requires 110 v, 60 cps outlet. Interior is constructed of stainless steel and unit is finished in gray vinyl plastic. Made by **General Photo Products Co. Inc.**, General Photo Bldg., Chatham, N. J.



For more data circle MD-61, Page 219

Direct Writing Oscillograph

Portable six-channel oscillograph is designed as a lightweight and compact instrument. The model BL-226 oscillograph is equipped with six Model BL 902A penmotors which permit the simultaneous recording of six channels of instantaneous electric or mechanical phenomena that can be converted to electrical signals in the frequency range of dc to 100 cps. Unit is 17 in. long, 14½ in. wide, 7½ in. high, and weighs 60 lb. Large window in top of instrument permits viewing the chart as information is being recorded. Controls provide starting, stopping, and selection of chart speeds of 5, 25, and 125 mm per second. Chart paper is 12 in. wide and available in rolls up to 420 ft. A 25-ft length of cable and junction box provides all the necessary outlets for connecting six Brush amplifiers to the oscillograph. As an accessory, a remote control box is provided permitting the operator to start and stop the chart drive from remote locations. Outlets are provided in both the oscillograph and control box to permit use of a floor switch. Made by **Brush Electronics Co.**, Equipment Div. 18H, 3405 Perkins Ave., Cleveland 14, O.



For more data circle MD-62, Page 219

Potentiometer Kit

Comprised of "unitized" type RVC 2 potentiometers, mounting plates, clamp rings, Servocalculator, and brochure, the Servotrol pot kit "B" permits the servo engineer to pre-

Designed Right

for RUGGED SIMPLICITY and LOW MAINTENANCE

DENISON HydrOILic

PUMP/MOTOR

For *Pump* or *Motor* duty at 2000 psi

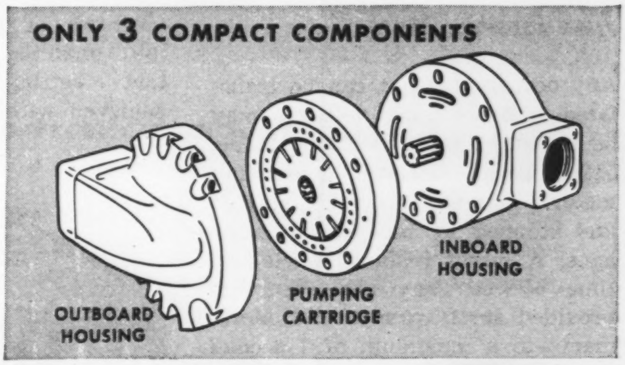
When you add *full hydraulic balance of both rotor and vanes* to design as simple and compact as Denison's rugged PUMP/MOTOR, you can expect smooth-acting efficiency that *holds up* under long, hard, continuous use.

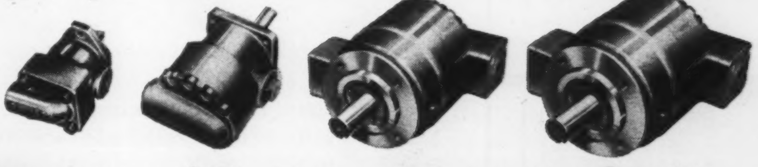
And you get it, in PUMP/MOTORS.

As the name indicates, PUMP/MOTORS meet *either* need—*without alterations of any kind.* They're ready to perform at full efficiency in *either direction* of rotation. With a choice of capacities in each of four basic PUMP/MOTOR sizes, they offer 11 different pumping sizes from 3.0 to 82 gpm—or fluid-motor torque ratings from 13 to 257 pound-inches per 100 psi.

You'll be ahead by filling pump and motor needs in the 2000 psi range with the smooth, balanced action and built-in reliability of Denison's dual-use, bi-directional PUMP/MOTORS. *Write today for Bulletin P-5.*

ONLY 3 COMPACT COMPONENTS





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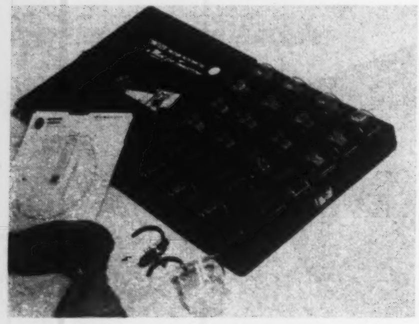
DENISON
TRADE MARK HydrOILics

The **DENISON** Engineering Co.
1156 Dublin Rd., Columbus 16, Ohio

pare single or ganged precision potentiometers for "bread-board" layouts. Wide selection of variable resistances are provided with 14 linear potentiometers having ranges from 0-100 to 0-100,000 ohms. One 360 deg sine potentiometer having 0 to 9500 ohms resistance is included. Each potentiometer is provided with three taps equally spaced along winding, giving four equal-resistance sections. With shunt resistors properly connected across taps, these four sections may be used to simulate nonlinear functions. Potentiometers have a 4-w power rating. Available from **Servotrol Co.,** Framingham Centre, Mass.



For more data circle MD-63, Page 219

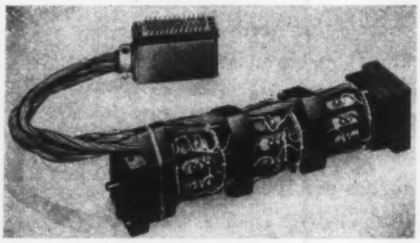
Time Interval Meter

Any occurrence that can be translated into changing voltages may be timed with the Berkeley Model 5120 time interval measuring meter. Timing may be started and stopped by independent voltages. A direct reading of elapsed time between any two events is provided in 1 microsecond increments to a maximum of 1 second with an accuracy of ±1 microsecond, ± crystal drift. Unit may be started and stopped by either positive or negative pulses by means of polarity selecting toggle switches. Attenuators permit selection of amplitude of start and stop voltages at optimum level for elimination of interference. Power is available from an accessory socket in unit to operate various transducers. Length of time that the digital reading is displayed can be controlled either manually or automatically up to a maximum of 5 seconds. Meter consists of a 1 megacycle crystal oscillator, input circuits, and electronic gate, and six Berkeley decimal counting units. The first event or voltage opens the electronic gate and the time interval between the two events is then displayed in direct decimal form in increments of 1 microsecond. No interpolation of any kind is necessary, as the total number is read directly, each digit of that number being indicated by the illumination of a single figure on each decimal counting unit. Instrument is 20¾ in. wide, 19 in. high, and 15 in. deep. Manufactured by Berkeley Scientific Co. Div., **Beckman Instruments Inc.,** 2200 Wright Ave., Richmond, Calif.

For more data circle MD-64, Page 219

Analog Digital Converter

Conversion of variable rotary positions of mechanical elements into unambiguous electrical contact settings are accurately achieved with this device. It digitizes functions which must maintain a zero reference and operate in a multidirectional counting method. Cumulative totals are continuously displayed in a lamp bank and at intervals chosen by the operator are recorded by a card-punching machine. Three decade unit shown can operate from −999 through 000 to +999 if an external relay which permits negative counting is incorporated. Standard system operates at speed of 250 number changes per second, but with special adapter unit this speed can be increased to 1600. Various applications include conversion of information obtained from analog computers and analyzers and from various strain-gage and potentiometer type sensing elements to feed electric typewriters or digital calculators. There is no limit to the number of decade units that can be assembled together. Available from **Genisco Inc.,** 2233 Federal Ave., Los Angeles 64, Calif.



For more data circle MD-65, Page 219

Lettering Guides

Designed to provide neat, equally spaced lettering for general purpose drafting is the Rapidesign No. 900 lettering set. It consists of three individual lettering guides for drawing modern type letters ⅛, 3/16, and ¼-in. high. Templates are sold individually or are available in durable folio. Made of 0.030-in. thick double-cured plastic, each template is precision milled for smoothness of line. Size of each guide is 6⅞ in. by 1⅞ in. Available from **Rapidesign, Inc.,** P. O. Box 592 Glendale, Calif.

For more data circle MD-66, Page 219

Photocopy Printer

Typewriter-size unit gives three copies of the original material reproduced on ordinary paper in one minute. Utilizing reflex printing the Kodak Verifax copies practically any typed, written, drawn, or printed originals through 8½ by 11 in. size, including books, magazines, and other paper printed on both sides. Matrix paper exposure furnished by bank of 7-w lamps which are timer con-

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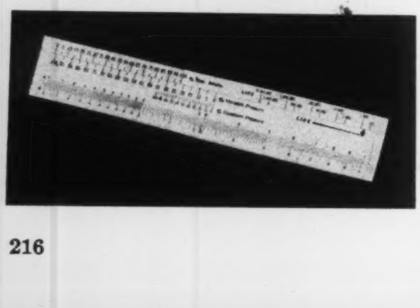
trolled. Thermostatically controlled heater keeps temperature of activator within proper range at all times. Sensitized matrix is first placed on top of lamp bank with material to be copied placed face down on top of matrix. After exposure, matrix is slipped into activator solution for 20 seconds. Matrix is then pulled under roller in contact with sheet of Verifax print paper or suitable ordinary paper to make copies. Unit finished in two-tone gray plastic and requires 110 v ac. Made by **Eastman Kodak Co.,** 343 State St., Rochester 4, N. Y.

For more data circle MD-67, Page 219

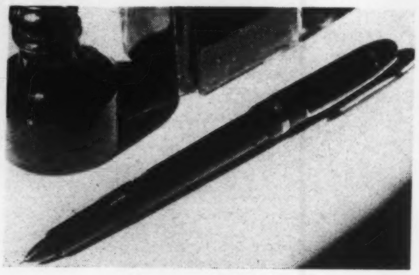
Bellows Slide Rule

Table of bellows characteristics and set of bellows templates are included in a "package" with slide rule. Basically suited to bellows manufactured by Clifford, this slide rule provides a convenient method for selecting any bellows for a particular application providing desired life, maximum deflection per convolution, and maximum internal and external pressure are known. When used in conjunction with the Clifford bellows table, rapid calculations of bellows life, permissible pressures and permissible stroke can be made. Slide rule has conventional C and D scale, list of decimal equivalents from 1/64-in. to 1 in., circle areas covering same range, 6 in. scale, and 15 cm metric scale. Bellows table lists total number of cycles per day, week, month, and year if frequency per second is known. Bellows in a variety of sizes can be traced from the templates. Slide rule is made of white plastic with a clear plastic indicator. Available from **Clifford Mfg. Co.,** 123 Grove St., Waltham, Mass.



For more data circle MD-68, Page 219

Inking Pen

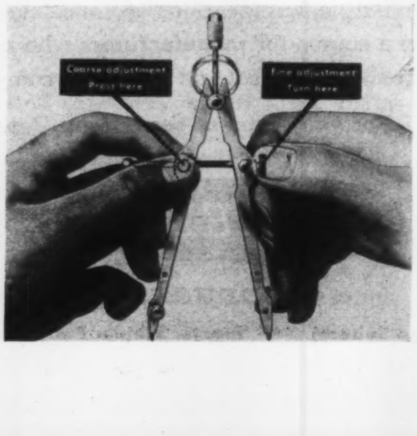


Designed with a piston-type filling device with a visible ink supply, the Rapidograph is claimed to be the first fountain pen for use with both regular and drawing inks. Self-cleansing, noncorroding mechanism quickly purges ink to be changed simply by filling with cold water. Introduced by **Koh-I-Noor Pencil Co. Inc.,** Bloomsbury, N. J.

For more data circle MD-69, Page 219

Bow Compass

Constructed for use with pencil and four types of pen attachments, a new compass know as the Vemco Speed-Bow draws circles from ⅛ to 10 in. diameter. Instrument has two types of adjustments with coarse settings being made quickly by a finger-pressure release and fine adjustments by a thumb screw. Manufactured by **V. & E. Mfg. Co.,** Box 950 M, Pasadena 20, Calif.



For more data circle MD-70, Page 219

Ammonia Whiteprinter

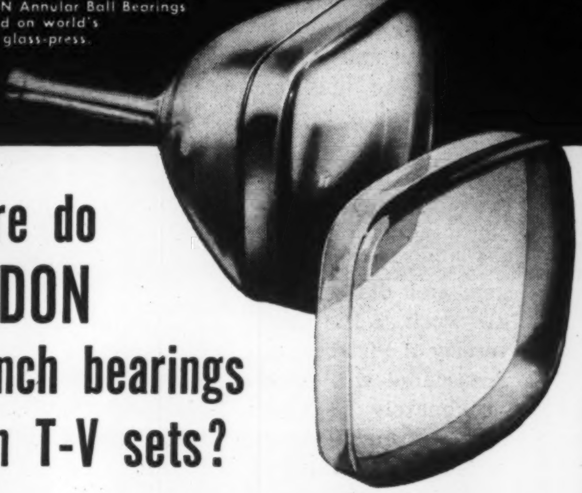
Printing and developing black line and colored line whiteprints in high volume is the outstanding feature of the Speed Master Model S Whiteprinter. It duplicates tracings, drawings, sketches, layouts, records, charts, data sheets, letters, or any translucent originals whether drawn, written, typed, printed, or photographed at printing speeds varying from 6 in. to 14 ft per minute. Unit is 68 in. wide, 62 in. high and 24 in. deep, and can handle cut sheets or roll stock up to 42 in. wide in any length. Uses 2000-w high-pressure Vicor jacketed mercury lamp and dry ammonia-fume method of diazo reproduction. Using 30 to 50 drops of 26 degree Baume (28% solution) per minute, it has large capacity stainless steel ammonia storage tank. Blower system provides cool contact glass surface to protect originals. Unit is adjustable for different weights and grades of sensitized paper. Operating on 220 v, single phase, 60 cycle ac, it draws 22 amp. Constructed with jig-drilled aluminum castings and has baked hammertone gray-green finish. Available from **Peck and Harvey,** 5650 N. Western Ave., Chicago 45, Ill.

For more data circle MD-71, Page 219

Contact KAYDON Muskegon

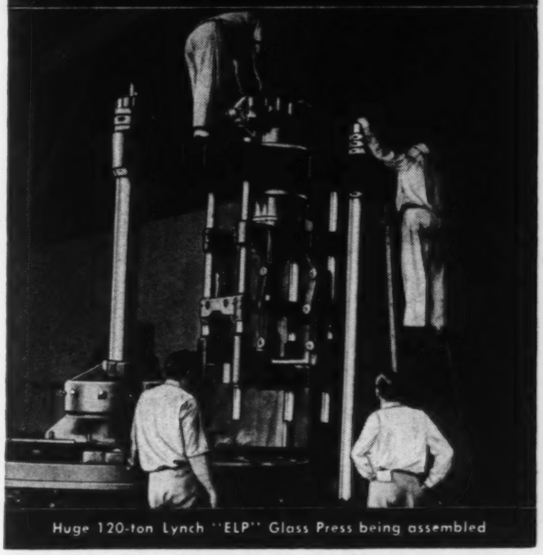
FOR ALL TYPES OF BALL AND ROLLER BEARINGS: 4" BORE TO 120" OUTSIDE DIAMETER

Two 31.000" x 25.000" x 3.500" KAYDON Ball Thrust Bearings, one 21.500" x 16.000" x 2.750" and one 20.500" x 15.500" x 2.500" KAYDON Annular Ball Bearings are used on world's largest glass-press.



Where do KAYDON 31-inch bearings fit in T-V sets?

5-ton table of press rides smoothly on KAYDON bearings



Huge 120-ton Lynch "ELP" Glass Press being assembled

Obviously there's no place for 31-inch bearings in 21-inch T-V sets . . . but four husky **KAYDON** super-precision bearings are vital factors in producing large T-V tube face-plates (21-inch and up), made on the world's largest glass-press, a product of Lynch Corporation, Anderson, Indiana.

KAYDON bearings were engineered into this huge Lynch "ELP" 120-ton toggle press to support its 5-ton table and to accurately guide the terrific pressure-strokes that form precision T-V face-plates from gobs of molten glass. Now mass production of face-plates is assured with unvarying precision and faultless interchangeability, for dependable T-V reception.

Similarly, **KAYDON** bearings help designers improve military equipment, aircraft, automotive and many modern heavy-duty industrial machines, to help manufacturers make precision products better, faster, more profitably. On machines you *make* to *sell*, or *buy* to *use*, specify **KAYDON** bearings. Capable **KAYDON** engineers are prepared to cooperate with your technicians. Contact **KAYDON**.

KAYDON Types of Standard and Special Bearings:
Spherical Roller • Taper Roller • Ball Radial • Ball Thrust • Roller Radial • Roller Thrust • Bi-Angular Bearings

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PRECISION BALL AND ROLLER BEARINGS

Crescent Valve Performance

HIGH

CYCLING

PLUS

TIGHT SEATS

AMAZING CONTROL

Continuous duty rating of 600 cycles per minute and bubble tight closure throughout the pressure range MEANS THIS TO YOU: No lag—you can squeeze and release spot welds, for example, with accuracy regardless of cycling rate. You can stop worrying about coil burn-outs. Besides, you get full flow through the valves, millions of cycles without maintenance, the lowest possible power consumption (relieving overloaded electrical facilities), an unlimited choice of voltages —AC or DC—by simply changing coils. Write for NEW catalog 3C-1 describing both 3-way and 4-way pilot operated Crescent Valves.

1/4" to 3/4" • 3-Way • Pressures to 500 psi

BARKSDALE VALVES

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MEN OF MACHINES

Joseph E. Mulheim

Jack & Heintz Inc., Cleveland, has appointed **Joseph E. Mulheim** to the position of chief engineer. Mr. Mulheim has been associated with the development of gas turbine starters and ac and dc generators for 15 years. He received a bachelor of science degree in mechanical engineering from the University of Michigan and did graduate work at the University of Pittsburgh. Associated with Westinghouse Electric Corp. for approximately 13 years, he served that company as assistant manager of aviation engineering immediately prior to joining Jack & Heintz.

The company has also appointed **S. Floyd Stewart** to the newly created post of assistant to the president. In this capacity he will devote the major portion of his activities to new product planning. Mr. Stewart was associated with the Leece-Neville Co. for 15 years, advancing from research engineer to president. He served as an executive vice president of the Arma Corp. before his new appointment.

◆

Chance Vought Aircraft Div. of United Aircraft Corp., Dallas, Tex., has announced the appointment of **W. R. Hedeman** as project engineer and **O. K. Bell** as assistant project engineer in the missile design section. Dr. Hedeman, formerly chief of research and development for the York Div. of Bendix Radio, will be responsible for the executive direction and coordination of electronics activity associated with missile guidance.

◆

Edward J. Horkey has joined Pastushin Aviation Corp., Los Angeles, as vice president in charge of engineering. He will direct design and development of jettisonable fuel tanks, as well as other research and development projects. Mr. Horkey was formerly chief technical engineer for North American Aviation Inc., where he was in charge of aerodynamics, wind

INERT G-E SILICONE FLUID *(LEFT)* WON'T ATTACK POLYETHYLENE, WHEREAS MINERAL OIL *(RIGHT)* EATS THROUGH, SO . . .

To keep your farads up – *Specify* G-E SILICONE FLUID

Pulse-type capacitors for testing and aging hydrogen-thyratron and magnetron tubes are now made by Tobe Deutschmann Corporation using General Electric silicone fluid SF-96 as the liquid dielectric. Why? Because this inert fluid does not attack the polyethylene solid dielectric or undergo copper-induced oxidation as do mineral oils. Besides chemical inertness, SF-96 has excellent electrical and physical properties like these:

Electrical Properties:

Dielectric strength (0.1 in. gap)	35-40 kv
Power factor (1 megacycle)*	0.0001
Dielectric constant*	2.7
Volume resistivity (at 500 volts D.C.)	10^{15} ohms/cm^3

**Relatively constant over a wide range of frequencies and temperature*

Physical Properties:

Available in viscosities from 40-1000 centistokes

Appearance	water-white, clear
Pour point	as low as –85 F
Volatility	extremely low
Flash point	580-600 F
Stability	resists oxidation up to 300 F
Heat transfer	excellent

You've seen how G-E silicone fluids helped this capacitor manufacturer. Find out how they can help you by sending the coupon today!

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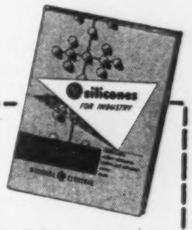
CLIP AND MAIL TODAY!



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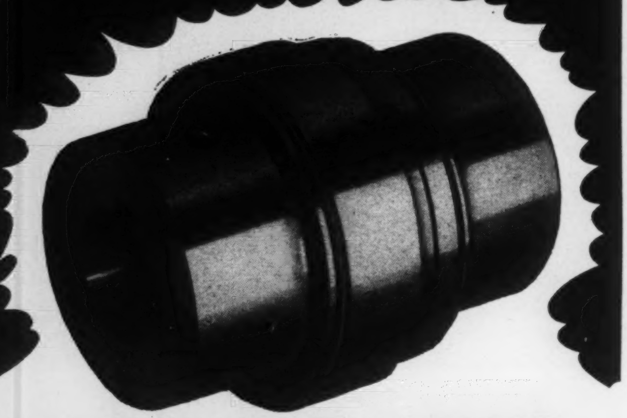

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◆

Allen S. Dunbar has joined Dalmo Victor Co., San Carlos, Calif., as assistant director of research. For the past three years Mr. Dunbar has been senior research engineer for the Stanford Research Institute.

◆

Marsh B. Hall

New chief engineer of the development and research engineering department of the Archer Ave. plant of Acme Steel Co., Chicago, **Marsh B. Hall** succeeds **James N. Wognum,** who has been named chief engineer of the company's newly created engineering research laboratory in Chicago. A graduate of Purdue University in mechanical engineering, Mr. Hall joined the development and research department in 1950 after serving as chief engineer at the Gatke Corp. and as chief engineer and factory manager at Acme Visible Records. He was made assistant chief engineer at Acme in 1952.

Willard S. Collins assumes Mr. Hall's former duties of assistant chief engineer. Mr. Collins joined the department in 1941 after serving in the plant engineering department of Swift and Co.

◆

Theodor F. Wutscher

Theodor F. Wutscher has been appointed chief designer of the Loewy Rolling Mill Div. of Hydropress Inc., New York. Mr. Wutscher received a degree in mechanical engineering from the Technical College, Vienna, Austria, in 1925, and after several years of practical experience in various machine manufacturing plants in Austria and Germany, was delegated as technical expert to Russia. There he headed a number of large engineering projects for the modernization of the nationalized rolling mill

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No wonder your shop squawks, these days, about every job that calls for skilled operators:

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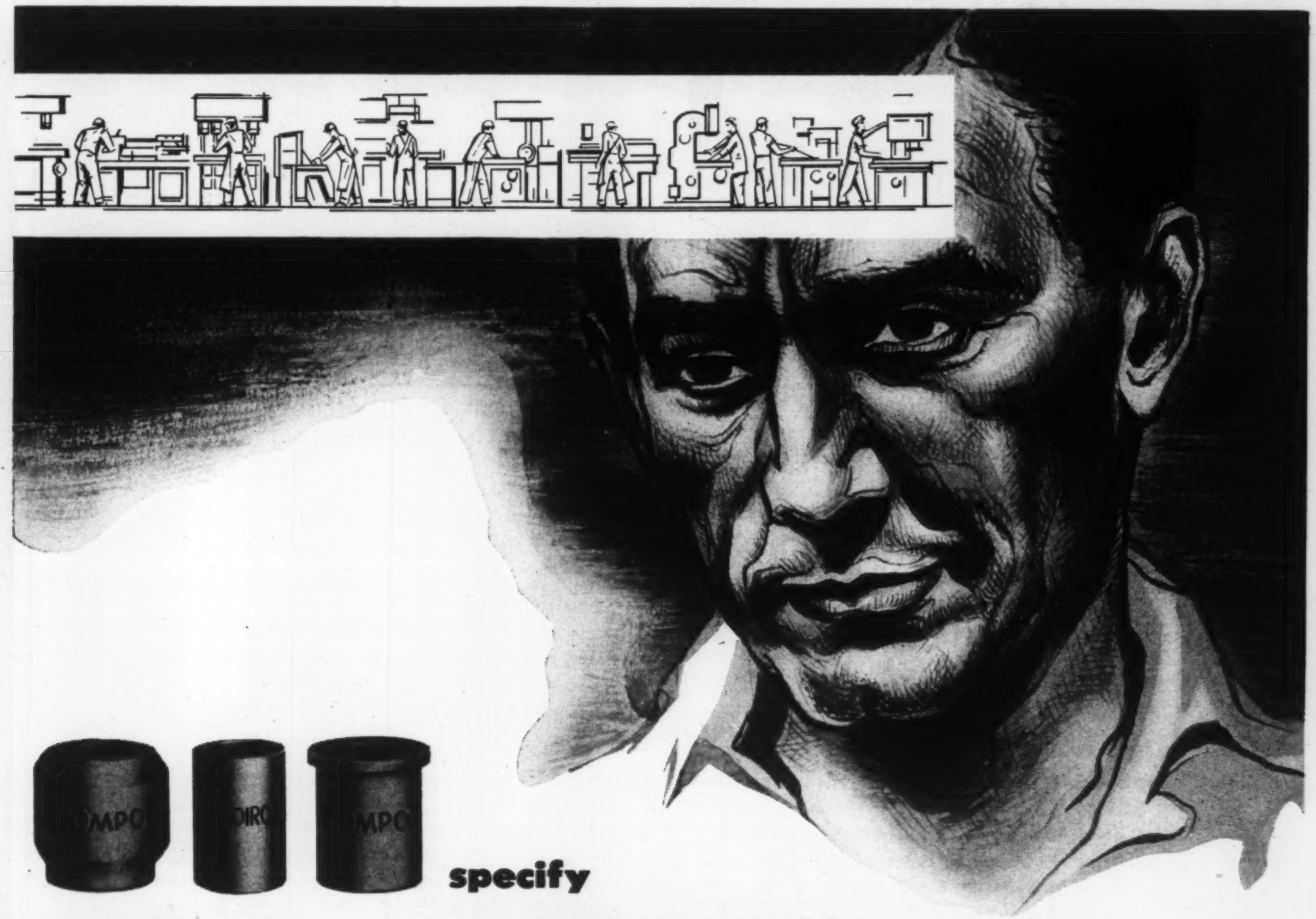

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(porous bronze) (sintered iron)

They need no reaming! A simple press fit sizes them to accurate as-installed I.D. Most of the time, they do away with the need for oil holes and fittings. That cuts out drilling and tapping operations.

Tell **Production** how these bearings speed up output.

Tell **Management** how they reduce costs.

Tell **Sales** how long they last, with little or no attention.

You'll find all the facts you need on these oil-retaining bearings—products of Bound Brook powder metallury—in our bulletins on advantages, application, installation, sizes. Just write for your copies.

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Combining . . .
AUTOMATIC REMOTE PILOT CONTROL
with the . . .
SAUNDER'S TYPE DIAPHRAGM VALVE

With this valve, you can bring into your flow control two desirable operating advantages:

- **You can install a non-clogging, tight-seating, corrosion and abrasion resisting, diaphragm valve suitable for corrosive liquids and gases.**
- **And at the same time obtain with it, dependable ASCO pilot control for automatic and remote closing and opening.**

You know the advantage of the Saunder's Type Valve. It's accepted throughout industry. What we have done is to give it compactness and simple automatic control. There are only two operating parts — solenoid and diaphragm. Valve uses commonly available auxiliary source of air, water or oil. This valve can be installed in any position and is available normally open or normally closed; *also with explosion-proof and watertight solenoid enclosures*. Controls flow in either direction. Wide selectivity in body and contact material provides bronze, stainless steel, cast iron, Saran and sanitary bodies, rubber or glass lined, etc. Pipe sizes: ½ to 2 inches; heights: 6⁵⁄₁₆ to 10¹⁄₁₆"; face to face: 2⅞ to 7".

This valve is but one of many ASCO Types, *all operating with automatic and remote control*. Literature, of course, is available but why not write us in detail about your problem? You'll be contacting "Electro-magnetic Control Headquarters". This has been our business for close to seventy years.

If you would like a copy of our New Solenoid Valve Catalog, for your files, be sure to let us know.

ASCO Solenoid VALVES
Automatic Switch Co.
387 LAKESIDE AVENUE · ORANGE, NEW JERSEY

installations. In 1937 Mr. Wutscher joined the Rolling Mill Div. of the Loewy Engineering Co. Ltd. in London and became one of the chief designers in special machinery and layout of plants. He came to the United States in 1951 and joined Hydropress Inc. as senior development engineer of the Rolling Mill Div.

◆

Chrysler Corp., Detroit, has named **Ira E. Johnson** as general manager of its new 3800-acre Engineering Proving Grounds near Chelsea, Mich. **Arnold Steckling** is chief engineer and assistant to the general manager, and **Wallace E. Zierer** is supervising experimental engineer.

◆

New manager of engineering of the Westinghouse Electric Corp. Switchgear Div. is **Charles P. West,** who joined the division in 1926. He has served in various capacities and since 1944 has been manager of the switchboard engineering department.

◆

Dodge Steel Co., Philadelphia, has promoted **Henry J. Kelly** to the position of chief engineer.

◆

Formerly manager of the physics and electrical engineering division, **Elmer H. Schulz** has been promoted to director of research at Armour Research Foundation of Illinois Institute of Technology, Chicago. Dr. Schulz will direct the research and development activities of more than 850 scientists and engineers.

◆

Bendix Home Appliances, division of Avco Mfg. Corp., South Bend, Ind., recently announced three engineering department promotions. **George W. Allen** has been named chief engineer for laundry equipment, and his former position of automatic washer engineer has been filled by **W. C. Wenzel. Spencer J. Kohlmann,** who was special project engineer, is now executive engineer in charge of laboratories, model shop, drafting and records.

◆

Associated Research Inc., Chicago, has announced the appointment of **Donald A. Davenport** as chief engineer.

◆

Cook Research Laboratories, a division of Cook Electric Co., Chicago, has promoted **Alton D. Anderson** to assistant chief engineer and **Jay Warshawsky** to technical director of the servomechanisms and automatic control systems section. Mr. Anderson has served the laboratories as director of the systems development section, working on oceanographic instrument development, digital computer research and design, rocket instrumentation and fluid dynamics research. Previously he was associated with the Naval Ordnance Laboratory as a research engineer and project engineer on the development of undersea weapons and as chief of the pressure mechanisms

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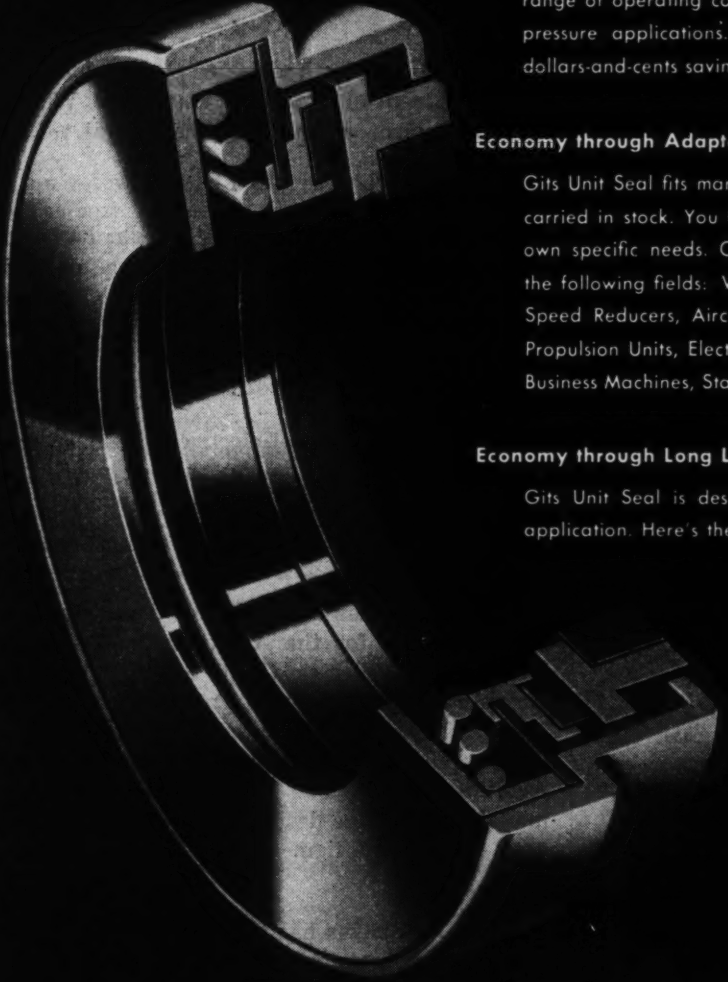

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Gits Unit Seal proves itself in dependable performance over a wide range of operating conditions—including extra-high speed, heat and pressure applications. Operation at peak efficiency always means dollars-and-cents savings.

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Gits Unit Seal fits many applications as a standardized item actually carried in stock. You harness the savings of mass production to your own specific needs. Gits Unit Seal already has wide application in the following fields: Washing Machines, Disposal Units, Gear Motors, Speed Reducers, Aircraft Turbine Pumps, Accessory Drive Units, Jet Propulsion Units, Electrical Power Equipment, Automotive Accessories, Business Machines, Standard and Special Machine Tools.

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Gits Unit Seal is designed for maximum life in any recommended application. Here's the real "proof of the pudding" in saving money.

Write Today For FREE Illustrated Brochure, or send us your seal problem. Our experienced engineering staff is at your service.

*Cartridge Seal . . . requiring only 25% more space than lip-type seals.

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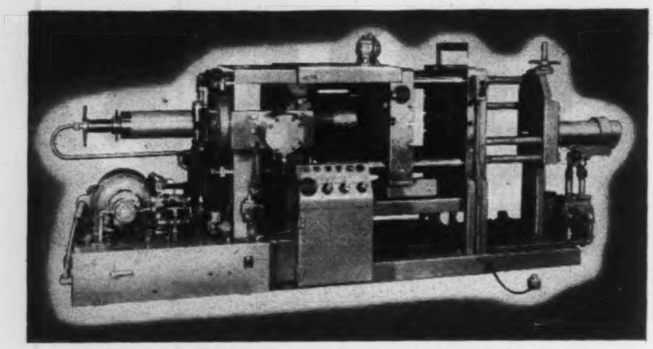
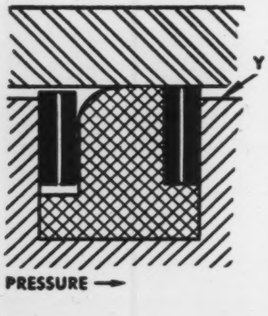
HOW PALMETTO G-T RING "showed" CUYAHOGA INDUSTRIES its superiority in PACKING PERFORMANCE



This Ohio firm was "from Missouri" where packing was concerned

At Cuyahoga Industries in Cleveland, Ohio, the Palmetto G-T Ring and a conventional packing were matched for performance in a Cuyahoga-made 600 ton Wedgelock Die Casting Machine. Results: The conventional packing with leather back-up rings extruded and had to be replaced within three months. Palmetto G-T Ring performed satisfactorily without replacement for over a year! When it's getting too tough for other packings, it's "just right" for G-T Ring.

THE KEY TO LONG SERVICE UNDER PRESSURE IS NON-EXTRUSION . . . THE KEY TO NON-EXTRUSION IS THE PALMETTO® G-T RING



As pressure is applied, conventional packings soon extrude into clearance space Y, then fail. Not so the G-T Ring! Because of its design consisting of a resilient sealing ring in a T-Section supported on each side by two non-extrusion rings, it cannot extrude. As pressure is applied to the G-T Ring, the resilient material flows under the non-extrusion rings, urging them against the cylinder wall and blocking the path of extrusion.

Interesting?

Write for your complimentary copy of the new Greene, Tweed manual. This helpful 32-page handbook for the design engineer covers Palmetto G-T Packings in detail—as well as other noteworthy Palmetto Molded Packings.

Our 90th Year Nearly a Century of Quality

packing more performance into every application PALMETTO Packings

GREENE, TWEED & CO. North Wales, Pa.

development section. Prior to joining Cook, Mr. Warshawsky was a design engineer for Lear Inc. He was also associated with Curtiss-Wright on aircraft instrumentation and was an instructor in the graduate division of Illinois Institute of Technology.

◆

Associated with the aircraft industry for 14 years, **C. C. Hurlburt** has joined Klincher Locknut Corp., Indianapolis, as director of engineering.

◆

Formerly chief engineer of Rosan Inc. and Rosan Engineering Co., Newport Beach, Calif., **Robert D. Weber** has been promoted to the position of director of engineering for both companies. Replacing Mr. Weber as chief engineer is **Arthur I. Lusk,** who was assistant to John K. Northrop and director of guided missile development for Northrop Aircraft Inc.

◆

John K. Northrop, aeronautical engineer and designer, has been retained as a consultant to the president of the Garrett Corp., Los Angeles.

◆

Wyman K. Ender has joined the products engineering department of Trane Co., La Crosse, Wis., to work on development of hermetic centrifugal refrigeration units.

◆

Heyl & Patterson Inc., Pittsburgh, has announced the appointment of **Ellis J. O'Brien** as chief development engineer to direct activities of the research and development department. Mr. O'Brien was formerly associated with the Vanadium Corp. of America.

◆

Assistant professor of electrical engineering at MIT, **David C. White** has joined the engineering staff of Holtzer-Cabot Div. of National Pneumatic Co. Inc., Boston, as a consulting engineer.

◆

R. L. Wells has been appointed assistant manager of engineering for the Aviation Gas Turbine Div. of Westinghouse Electric Corp., South Philadelphia, Pa. He entered the company's graduate student course in 1940 and became associated with the Research Laboratory the following year. In 1945 he joined the Aviation Gas Turbine Div., where he last served as manager of engine design. **P. G. DeHuff** is now manager of engine design.

◆

David A. Blevins has been appointed production engineering supervisor of Electric Regulator Corp., Norwalk, Conn. He was formerly chief engineer of Shank Metal Products Co.

◆

Sterling Engineering Co., Laconia, N. H., subsidiary of American Machine & Foundry Co., has named **Kenneth A. Killam** to the position of vice president in charge of engineering.

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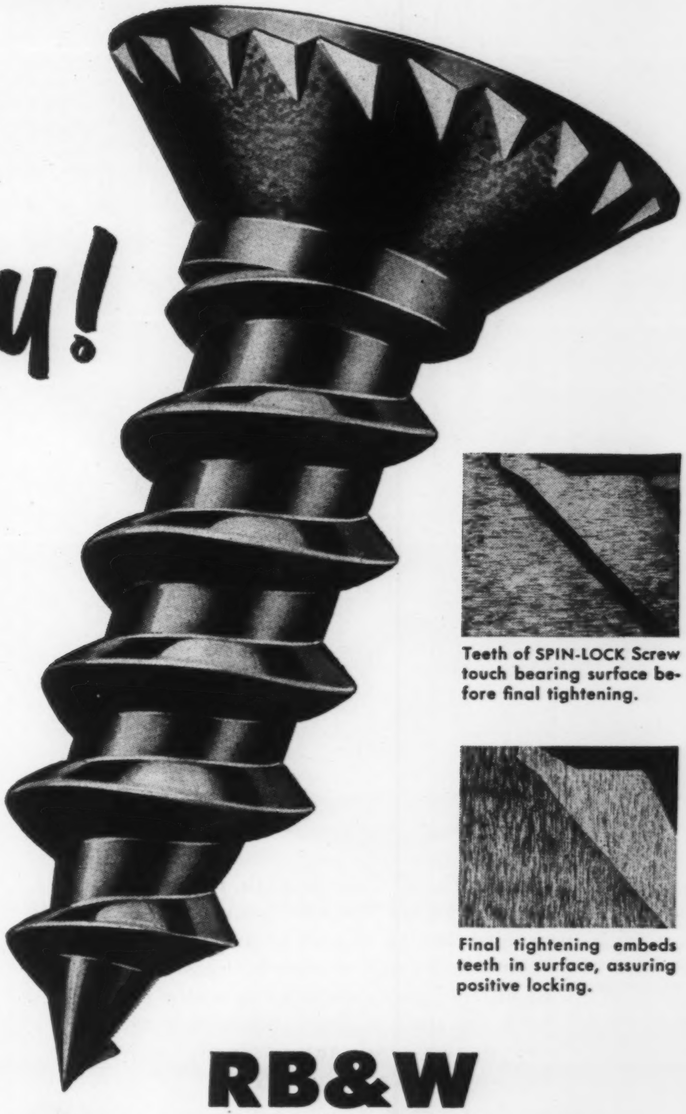
Saves Money!



You're 'way ahead of the game with RB&W's unique new SPIN-LOCK Screw—it saves you money right down the line with its exclusive *one-piece* construction. Here's why:

Workers do more fastening in less time. There's no washer to add. And it's easy to drive SPIN-LOCK in hard-to-reach spots.

Purchasing and inventory costs drop. There's just one requisition to fill . . . one part to stock, because SPIN-LOCK does away with the need for washers.

Accidents and lost time go down. There's no projection on SPIN-LOCK to catch fingers or clothes. No special handling is required, either.

SPIN-LOCK holds tighter under vibration than ordinary fasteners. Ratchet-like teeth under the head lock into the surface when assembled. Hex, pan, truss, flat heads.

Write to Russell, Burdsall & Ward Bolt and Nut Company, Port Chester, N. Y., for free booklet containing complete data and specifications on the SPIN-LOCK Screw.

RB&W—The Complete Quality Line. *Plants at:* Port Chester, N.Y., Coraopolis, Pa., Rock Falls, Ill., Los Angeles, Calif. *Additional sales offices at:* Philadelphia, Pittsburgh, Detroit, Chicago, Dallas, San Francisco. *Sales agents:* Portland, Seattle. Distributors from coast to coast.

B.3.3

Teeth of SPIN-LOCK Screw touch bearing surface before final tightening.

Final tightening embeds teeth in surface, assuring positive locking.

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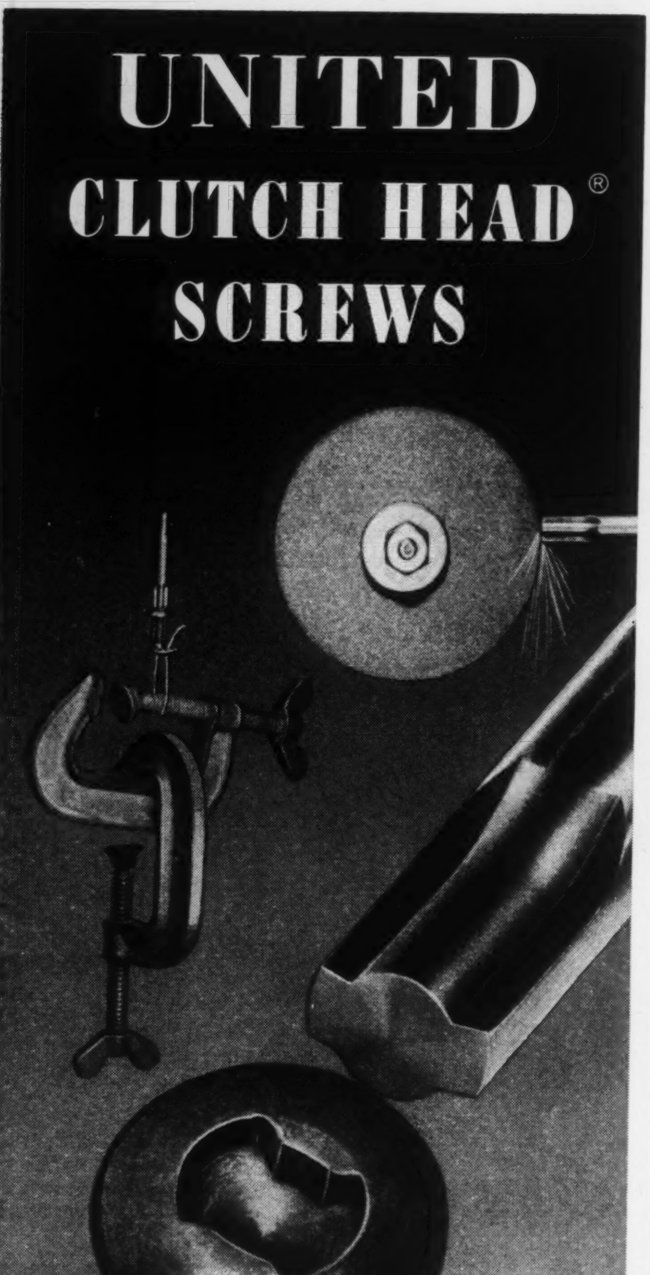

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THE ENGINEER'S Library

Recent Books

Mechanics of Materials. *By Seibert Fairman and Chester S. Cutshall, professors of engineering mechanics, Purdue University; 430 pages, 6 by 9 inches, clothbound; published by John Wiley & Sons Inc., New York; available from* MACHINE DESIGN, *$5.75 postpaid.*

The elements of mechanics of materials, also called strength of materials or resistance of materials, are presented in a thorough manner in this fundamental text. Numerous illustrative example problems, completely solved, are dispersed throughout the book. The appendix is composed of 14 tables including values of specific weights, stresses, moduli of elasticity and factors of safety of all common materials.

•

Simplified Drafting Practice. *By W. L. Healy and A. H. Rau, General Electric Co.; 166 pages, 8½ by 11¼ inches, clothbound; published by John Wiley & Sons Inc., New York; available from* MACHINE DESIGN, *$5.00 postpaid.*

This new book advances the basic idea that drafting can be stripped of its frills while retaining clarity of presentation and accuracy of dimension. It proceeds to demonstrate how simplification of delineation, the elimination of nonessentials, and extensive use of freehand drawing can often produce a time saving of 30 to 50 per cent. Many "before and after" illustrations are included along with explanations of freehand drawing, use of symbols, mechanical aids, and abbreviations.

•

Metadyne Statics. *By Joseph M. Pestarini; 431 pages, 6 by 9 inches, clothbound; published jointly by the Technology Press of the Massachusetts Institute of Technology and John Wiley & Sons Inc., New York; available from* MACHINE DESIGN, *$9.00 postpaid.*

In studying commutation in the 1920's, Dr. Pestarini recognized and defined a new group of electric machines to which he gave the name, "metadynes." A metadyne is an electric machine provided with an armature having a commutator upon which bear at least three brushes per cycle of the machine. These basic type machines are often referred to as cross-field or armatured-excited dynamos, and modifications of metadynes are familiarly known as amplidynes in this country. Both units were applied to automatic control of guns, radar trackers, and many other purposes during the war. Dealing with

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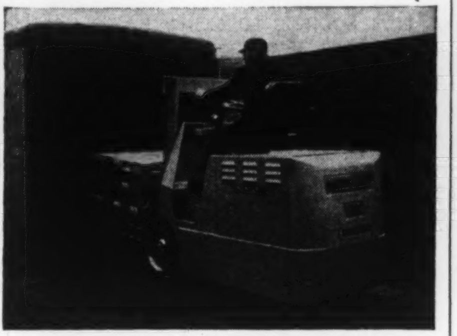
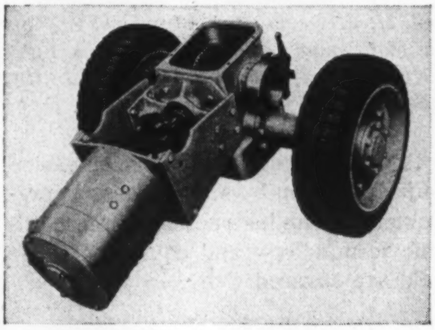
Motor Design Provides High Overload Capacity On Mercury "Yak" Trucks

Use of series wound, vehicle-type traction motors which are designed to provide high overload capacity is one of the factors contributing to the outstanding performance of the "Yak" Tilting Tiering Fork Trucks built by The Mercury Manufacturing Company, Chicago.

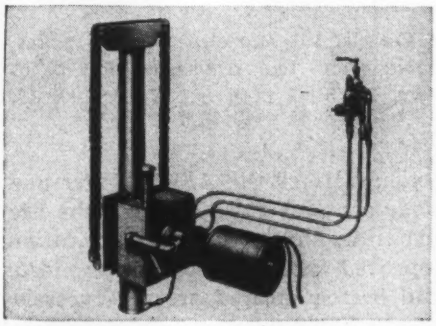
Two of these motors are used on every truck: one on the axle drive assembly, the other to drive the pump in the hydraulic hoist and tilt system.



A Mercury "Yak" Model 430 truck removing pallet load of welding wire from motor truck at receiving dock of industrial trailer manufacturing plant.

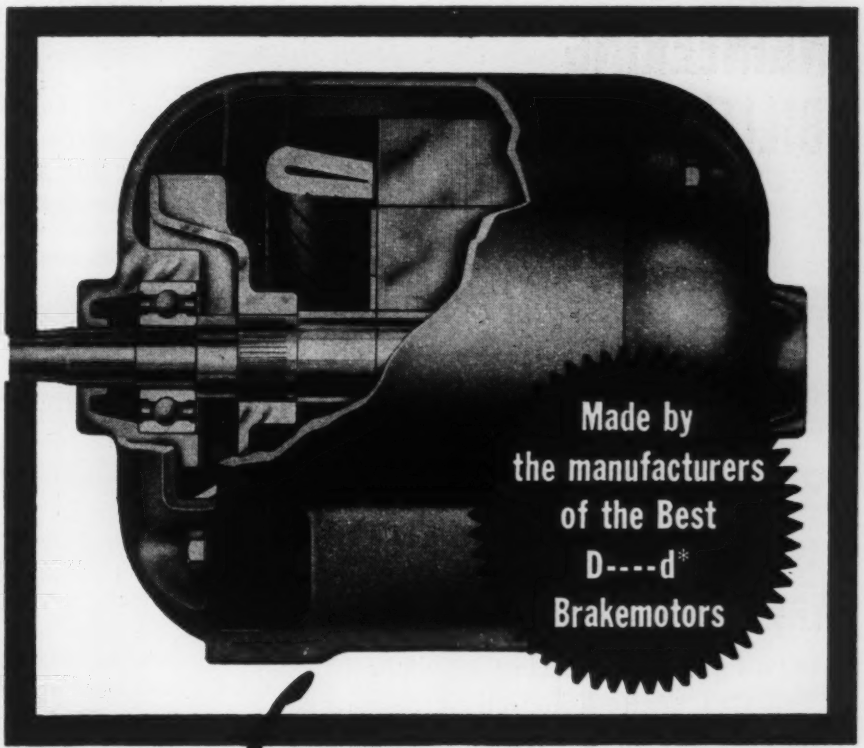


Drive axle of the "Yak" Model 430. Vehicle type motor shown at left provides high overload capacity.



A second vehicle-type series motor powers the pump for hydraulic hoisting and lowering and for fork tilting.

These high-overload capacity series motors used on every "Yak" truck are engineered and built by Star-Kimble, Motor Division Miehle Printing Press and Mfg. Co., 201 Bloomfield Avenue, Bloomfield, New Jersey. Basic information on these and other types of d-c motors is contained in Bulletin B1001, available on request from the manufacturer.



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because

Extra insulation
—three separate wrappers on every coil—provides added safety factor for possible rises above rated temperature.

Prelubricated bearings
—double-width cartridge type—run for years without any attention.

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keeps motor windings cool.

Dynamic balancing
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For further information, write for Bulletin B-201

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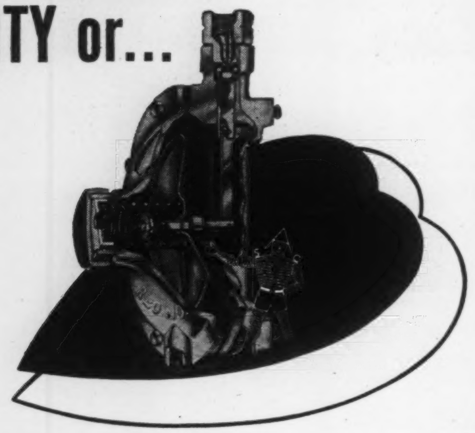

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theory, design, and application of metadynes, the text emphasizes the provision of specific characteristics particularly suited to each application rather than the mere adaptation of existing equipment. Typical applications of metadynes include controlling excitation of alternators or current in large dc generators and operating as motors and generators.

◆

Nomography and Empirical Equations: *By Lee H. Johnson, dean and professor of civil engineering, Tulane University;* 160 *pages,* 6 *by* 9¼ *inches, clothbound; published by John Wiley & Sons Inc., New York; available from* MACHINE DESIGN, $3.75 *postpaid.*

The purpose of this book is to explain two useful techniques for handling data, namely, nomographs, which provide quick graphical answers, and empirical equations which are mathematical expressions that closely approximate curves of plotted data over limited regions. The only mathematical background required is an elementary knowledge of analytical geometry and logarithms. Many illustrative problems are solved throughout the text showing methods of approach in various situations.

◆

Drafting by the Model Method. *By J. B. Musacchia, H. A. Fluchere, and M. J. Grainger;* 143 *pages,* 8½ *by* 11 *inches, paper or clothbound; published by Arco Publishing Co. Inc., New York; available from* MACHINE DESIGN, $3.50 *paperbound or* $5.00 *clothbound.*

Utilizing paper three-dimensional models for easier visualization of objects, a step-by-step process is presented by this booklet for the instruction of mechanical drawing. Basic terminology and equipment used in the drafting field are covered.

Association Publications

Unfired Pressure Vessels. 101 *pages,* 8½ *by* 11 *inches, paper-bound; available from The American Society of Mechanical Engineers,* 29 *West 39th St., New York* 18, *N. Y.,* $3.50.

This revised section VIII of the *ASME Boiler and Pressure Vessel Code* contains rules covering the use of all classes of materials and methods of fabrication that have been approved for construction of welded, riveted, forged, and brazed unfired pressure vessels.

◆

Standards—Engineering Tools for Industry. 64 *pages,* 8½ *by* 11 *inches, paperbound; available from the American Standards Association Inc.,* 70 *East 45th St., New York* 17, *N. Y.,* $2.00.

This booklet contains the proceedings of the Third National Standardization Conference and the prin-

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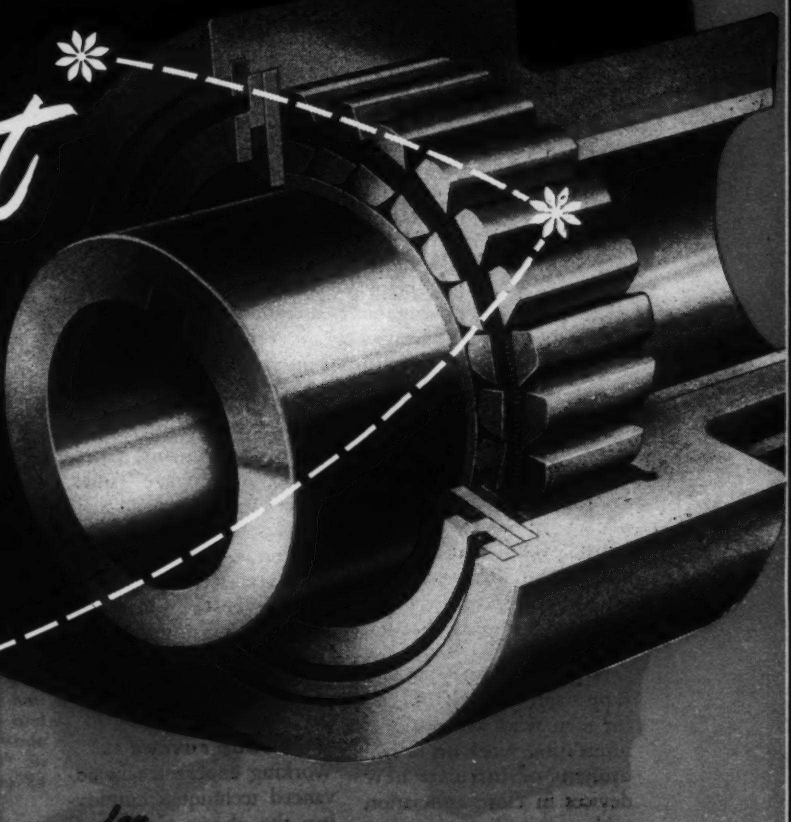

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cipal addresses presented by the medalists at the 34th annual ASA meeting award luncheon.

◆

Handbook of Manual Materials Handling Equipment. *48 pages, 8½ by 11 inches, paperbound; available from Caster and Floor Truck Manufacturers' Association, 27 East Monroe St., Chicago 3, Ill.,* $1.00.

Information concerning pneumatic, semi-pneumatic, solid rubber-tired, steel, pressed, and cast industrial wheels make up the first section of this handbook. Material on casters, hand and platform trucks, and pallets and skids are also included.

◆

SAE Aeronautical Drafting Manual. 220 *pages,* 8½ *by* 11 *inches, loose-leaf; available from Society of Automotive Engineers,* 29 *W.* 39*th St., New York* 18, *N. Y.,* $4.50; 38-*page revision kit for third edition,* $2.00.

A fourth edition, this manual fulfills the need for a more complete standardization of drafting practices to insure uniform interpretation of drawings in the aeronautical industry. Revisions to the third edition include changes or additions concerning dimensioning tolerances and interchangeability, abbreviations, definition and interpretation of terms, torsion springs, twist-drill data, and wrench clearance.

◆

American Management Association Series. *Each publication is* 6 *by* 9 *inches, paperbound; copies available from American Management Association,* 330 *W.* 42*nd St., New York* 36, *N. Y.;* $1.00 *each for members and* $1.25 *for nonmembers.*

The following publications are available:

Manufacturing Series

202. **Organizing for Improved Production and Cost Control**—68 pages.
203. **Motivating the Employee on Today's Production Front**—51 pages.
204. **Organizational and Personnel Problems of the Manufacturing Executive**—43 pages.
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Personnel Series

144. **Operating Problems of Personnel Administration**—40 pages.
145. **Practical Approaches to Supervisory and Executive Development**—42 pages.

Manufacturers' Publications

Broaching Practice. 80 *pages,* 8½ *by* 10½ *inches, paperbound; available from National Broach & Machine Co., Detroit, Mich. on company letterhead request.*

Origin, general advantages, typical applications and limitations of broaching are presented in the first chapter of this manual. The following chapters cover types of broaching and broach terms, cutting action, cutting fluids, design, manufacture, handling and

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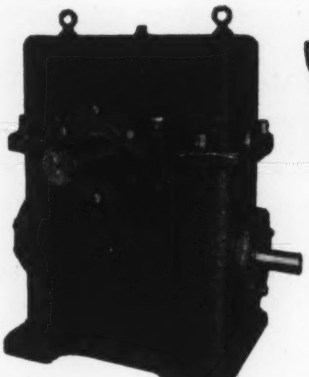

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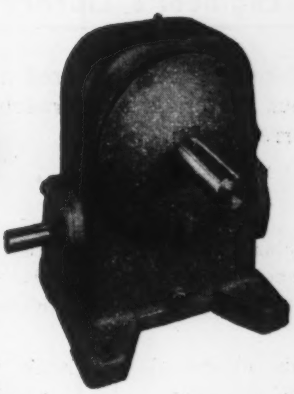

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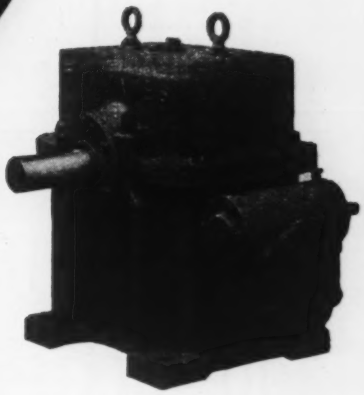

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maintenance. Also covered are the broachability of various materials and broaching troubles and ways to correct them.

◆

Machine Tool Electrical Handbook. 200 *pages, 8½ by 11 inches, clothbound; available from Westinghouse Electric Corp., Pittsburgh, Pa., on company letterhead request.*

This electrical handbook provides a convenient source of information for selection and application of motors and controls for the machine tool industry. In addition to performance data, ratings and dimensions, it discusses torque, horsepower, speed, insulation, codes, and external conditions.

Government Publications

NACA Technical Series. *Each publication is 8 by 10½ inches, paperbound, side-stapled; copies available from National Advisory Committee for Aeronautics, 1924 F St., N.W., Washington 25, D. C.*

The following Technical Notes are available:

2792. **Direct-Reading Design Charts for 24S-T3 Aluminum-Alloy Flat Compression Panels Having Longitudinal Formed Hat-Section Stiffeners and Comparisons with Panels Having Z-Section Stiffeners**—71 pages.

2890. **A Linear Time-Temperature Relation for Extrapolation of Creep and Stress-Rupture Data**—49 pages.

2928. **Axial-Load Fatigue Properties of 24S-T and 75S-T Aluminum Alloy as Determined in Several Laboratories**—63 pages.

2934. **Relation between Roughness of Interface and Adherence of Porcelain Enamel to Steel**—29 pages.

The following Technical Memorandum is available:

1353. **Some Problems of the Theory of Creep**—19 pages.

New Standards

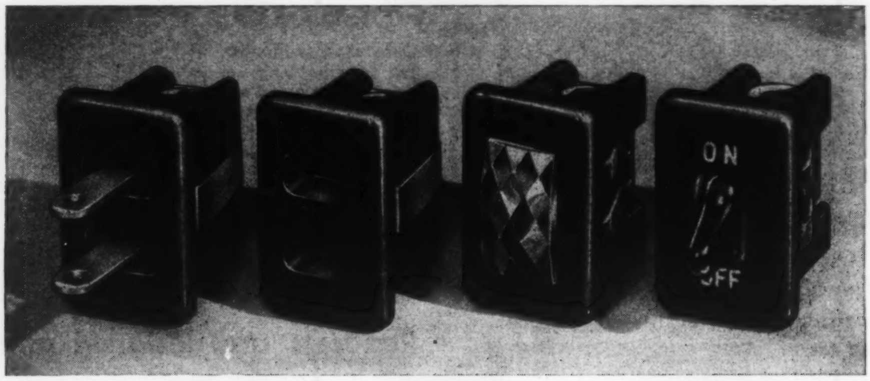
Machine Tapers. *ASA B5.10-1953; 15 pages, 8½ by 11 inches, paperbound; copies available from American Society of Mechanical Engineers, 29 W. 39th St., New York 18, N. Y.; $1.00 per copy.*

American standard practice for the slope of self-holding and steep machine tapers, the detailed dimensions for this type of taper tool shank, and the corresponding dimensions for the taper socket in the spindle of the machine are established in this standard.

◆

Plain Washers. *ASA B27.2-1953; 6 pages, 8½ by 11 inches, paperbound; copies available from American Society of Mechanical Engineers, 29 W. 39th St., New York 18, N. Y.; $1.00 per copy.*

Nominal thicknesses in Birmingham gage sizes and inches and outside diameters for plain washers with inside diameters ranging from 5/64 to 3⅛ inches are covered. Notes covering general applications, materials, tolerances, and defect limitations are included.



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Bethlehem bolts are good bolts. They have strong heads and shanks, and smooth-fitting threads. You can count on them for dependable performance.

If you need bolts—or any kind of fasteners—in your business, get in touch with the nearest Bethlehem sales office. Chances are good that we can supply you.

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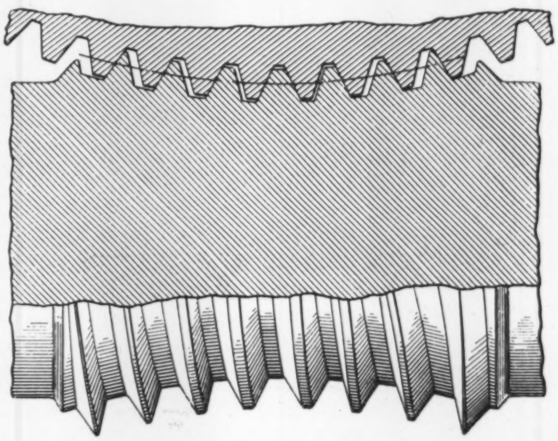
NOTEWORTHY Patents

SHOCKFREE TORQUE TRANSMISSION for high-reduction worm drives is obtained with a novel design of gearing detailed in patent 2,619,845. Rated capacities higher than for conventional gear sets of comparable size are produced by using a standard hourglass worm with relieved threads and a gear with dished teeth. Full driving contact between the worm and gear occurs gradually, eliminating shock and assuring adequate lubrication of the mating parts. In addition, the design facilitates mounting and simplifies manufacturing requirements. The patent has been assigned to Foote Bros. Gear and Machine Corp. by Arthur Mackmann and Bertel S. Nelson.



HIGH-PRESSURE SEALING of reciprocating shafts over prolonged periods of time is provided by a seal detailed in patent 2,625,414. Assigned to E. I. du Pont de Nemours & Co., the seal is designed as a thick metal diaphragm to withstand pressure differentials in excess of 10,000 psi with gases or liquids. Sealing action of the [illegible], which is held to a clearance of 0.0005 to 0.0008-inch, is provided by distortion caused at high pressure. An auxiliary gasket and stuffing box are employed. Construction of the seal minimizes scoring and wear. Assignor of the patent is William Kranz.

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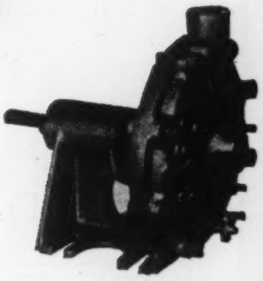
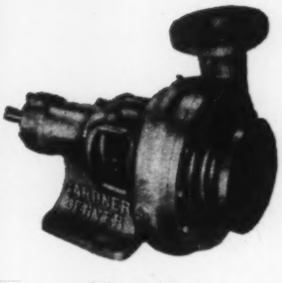
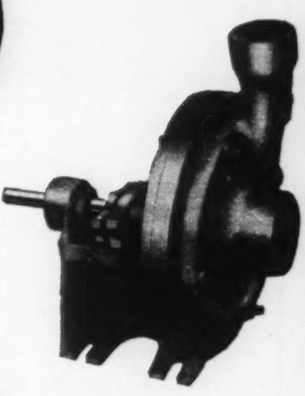


Model CAY (Reversible)



Model BA



Models B & C

Models BE & CE

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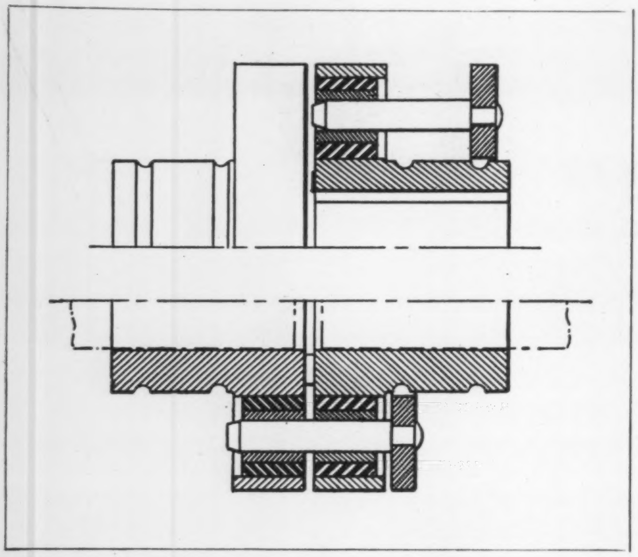
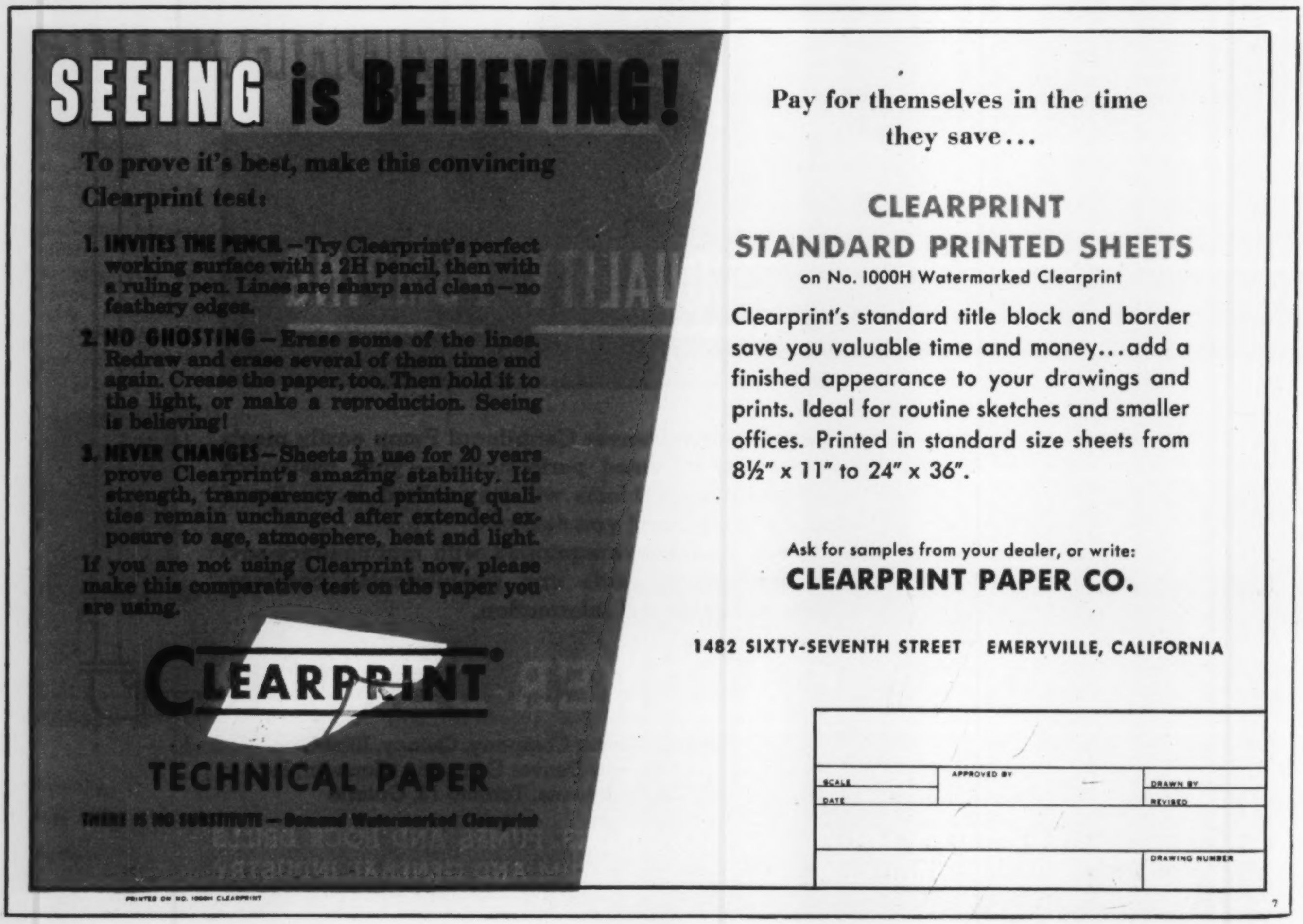
THE QUALITY LEADER IN COMPRESSORS, PUMPS AND ROCK DRILLS
FOR CONSTRUCTION, MINING, PETROLEUM AND GENERAL INDUSTRY

by Wayne I. Belden and detailed in patent 2,619,211, the coupling employs a sliding ring carrying a number of flexible pins which can readily be inserted or withdrawn as a unit from matching holes in flanges on the two shafts. A spring clip locks the ring in either coupled or uncoupled position. Different power requirements can be met by varying the number of pins used. Several modifications for different types of misalignment compensation are described in the patent assigned to Ajax Flexible Coupling Co. Inc.



HIGH INERTIA BRAKING for drive shafts, regardless of direction of rotation, is achieved with a novel limit stop mechanism designed by Alfred Krell. Assigned to Arma Corp. under patent 2,620,911, the mechanism employs a nut mounted on a threaded sleeve, which is spline-connected to the drive shaft, to actuate two sets of braking disks. In operation, rotation of the shaft causes the nut to travel in one direction, applying pressure to a set of the braking disks; at the same time the sleeve is displaced in the opposite direction to compress the other set of disks. Large inertia loads can be stopped within a few revolutions without shock. In addition, a lost motion action device incorporated in the mechanism prevents seizure in braking.

AUTOMATIC PRESSURE CONTROL for hydraulic circuits is afforded by a valve assigned to the Denison Engineering Co. under patent 2,619,112. Designed by Wendell E. Renick, the valve is used between the supply and demand sides of a circuit requiring a constant-pressure flow of fluid. Under normal operating conditions fluid flow is through the valve to working circuit and back to the reservoir. As pressure begins to build



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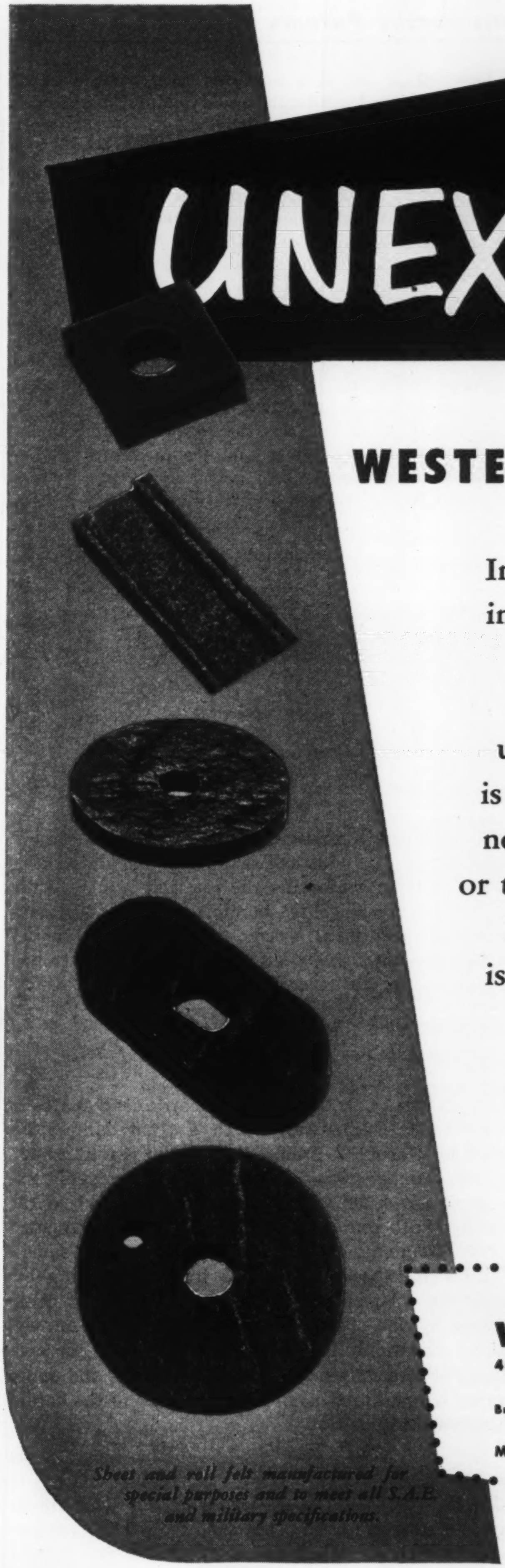

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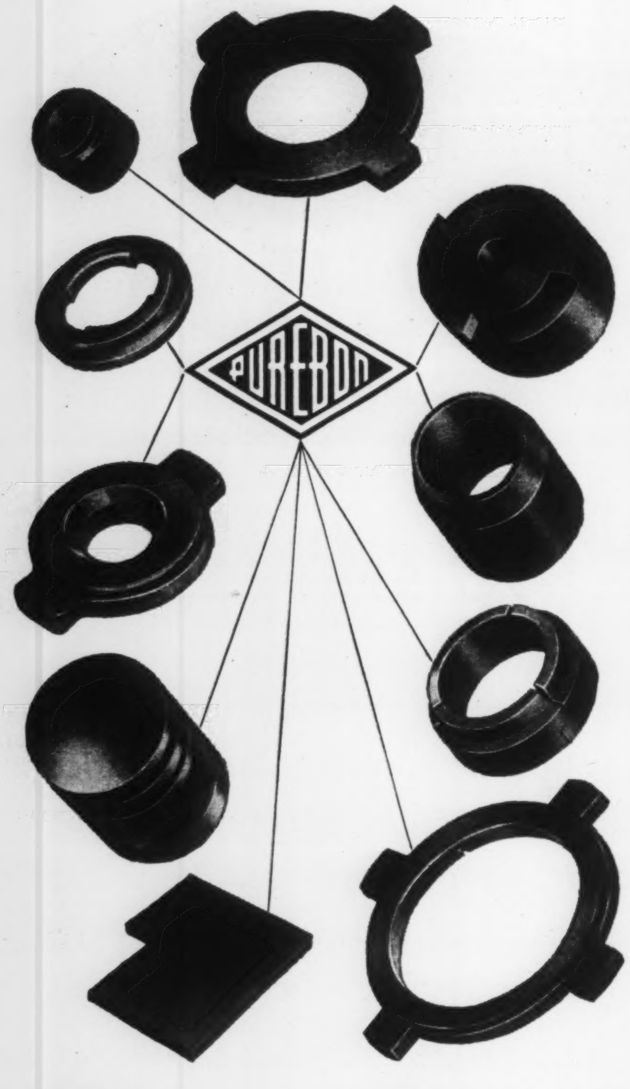

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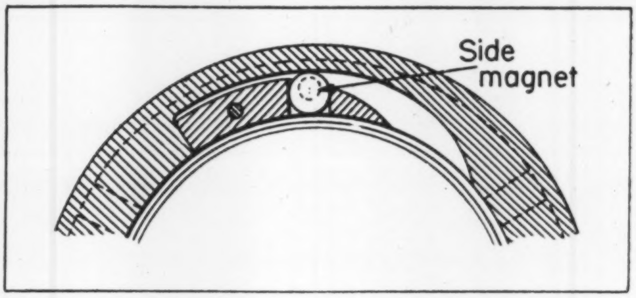
up, however, a piston is actuated to bypass some of the fluid directly back to the reservoir and maintain a constant-pressure flow from the valve. A relatively narrow operating range is provided; adjustment of the delivery pressure can be made with an external adjusting screw. Construction of the valve minimizes fluid foaming at high velocities and assures stable operating characteristics.

•

ONE-WAY CLUTCHING at high speeds is accomplished magnetically in an overrunning clutch assigned to General Electric Co. by Hugh M. Stephenson. Clutching action is provided by rollers floating in wedge-shaped slots between the rotating clutch members. Complete engagement or disengagement is assured by an arrangement of permanent magnets and iron bands which produce a force to actuate the rollers whenever there is relative movement between the rotating parts. In addition, small side magnets keep the rollers from contacting the rotating surface while the clutch is freewheeling, minimizing frictional losses at the high rotational speeds. Covered in patent 2,624,435, the clutch has been designed for use with gas turbines to prevent overdriving of the electric starting motor.



ROTATIONAL DAMPING of instrument shafts is accomplished magnetically with a fluid damper invented by Harold T. Faus. Detailed in patent 2,622,707, the damper consists of a stationary magnet external to a tubular section which is attached to the rotating shaft and carries a magnetic rotor immersed in oil. Damping action proportional to the square of the shaft speed is provided by fluid friction between the oil and rotor, which is prevented from rotating by the stationary magnet. Described in several modifications, the damper may be used for continuous or intermittent rotation applications and under varying temperature conditions. Assignee of the patent is General Electric Co.

Copies of all patents presented in this department may be obtained for 25 cents each from The Commissioner of Patents, Washington 25, D. C.

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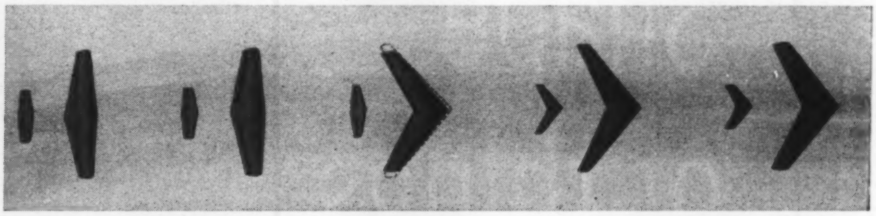
Engineering News Roundup

Latest Sabre Jet Is Result of Evolution

A new Sabre Jet, the North American F-86H, recently made its first flight. More powerful than previous Sabres, it is said to be a completely new airplane designed for service as both a day fighter and a fighter-bomber. Powered by a General Electric J-73 engine with considerably more thrust than previous models, the "H" is in the 650 mph class, has a combat radius of over 600 miles and a service ceiling in excess of 45,000 feet.

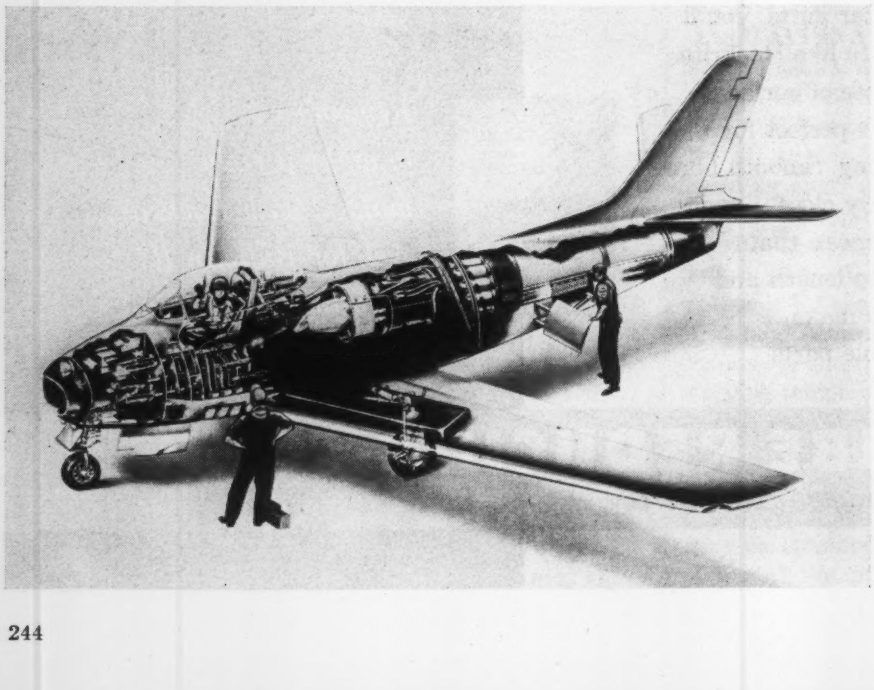
Although labeled "new," the F-86H is the result of an evolutionary process which began when several airframe configurations were submitted to the Air Force by North American in 1944. A contract for three airplanes of the chosen configuration, designated the XF-86, was received in 1945; however, wind tunnel tests convinced the designers that swept-wings would give the XF-86 about 70 mph greater top speed than the accepted straight wing design, and the present wing form of the Sabre was accepted by the Air Force late in 1945.

The following years brought many improvements in power plants, wing and fuselage structure and control systems. All of these improvements are combined in the F-86H, an entirely new airplane, but still a Sabre Jet, using the wing and tail surface configuration established in 1945 and proved in four previous models.



Evolution of Sabre wing and tail surface configuration. From left to right: F-51 Mustang wing, original Sabre wing, two intermediate wind-tunnel designs and the final swept-wing configuration

Phantom view of a Sabre Jet shows how engineers have utilized available space. Workman near tail of plane has his left hand on one of the speed brakes which can be opened at sonic velocities for deceleration



Selsyns Aid 3-D Projection

Selsyns are finding a new application as synchronizing devices which keep two motion picture projectors running in unison for stereoscopic pictures. Cameras equipped with selsyns can also operate independently for standard films.

Formerly two cameras were joined by a steel shaft when using the new "Natural Vision" projection technique. The spinning metal bar consumed needed space in the projection booth and made loading of the film difficult. The General Electric selsyn system eliminates the coupling process and replaces the shaft with wall or floor-mounted wiring.

The system is composed of two general-purpose selsyn generators, each slightly smaller than a ¼-horsepower motor. One is linked to each projector motor by a short chain and sprockets. The selsyns are interconnected by three wires.

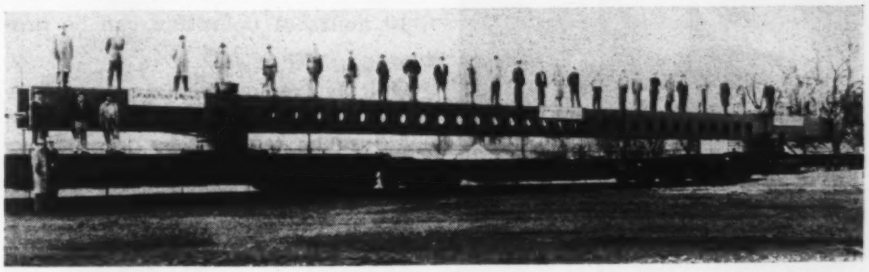
If one projector runs faster than the other, causing a difference in the timing of the pictures appearing on the screen, differential current flow between the selsyns creates a torque difference which speeds up the slower motor and slows down the faster one until they are back in unison. Response is said to be so rapid that audiences are unaware of the automatic action.

Stretcher Will Shape Large Aluminum Extrusions

A stretcher with 3 million pounds of pull will shape aircraft parts at Aluminum Co. of America's Lafayette, Ind., works. It will straighten and relieve strain in large aluminum extruded parts which will be made on two extrusion presses of 14,000 and 20,000 tons capacity at the Lafayette works as part of the United States Air Force heavy press program.

During extrusion, large pieces of metal tend to warp or curve, building up internal strains. To guarantee freedom from these residual strains and to straighten the extruded part, the strains and warps must be removed. Such difficulties are overcome in a single operation. Alcoa's stretcher, the largest yet built, is mounted on a foundation of 1500 cubic yards of concrete that has 23 tons of steel reinforcing bars and 12 tons of steel floor plate. Nine tons of aluminum-tread pontoon-bridge sections are used for walks to provide working access to the machine.

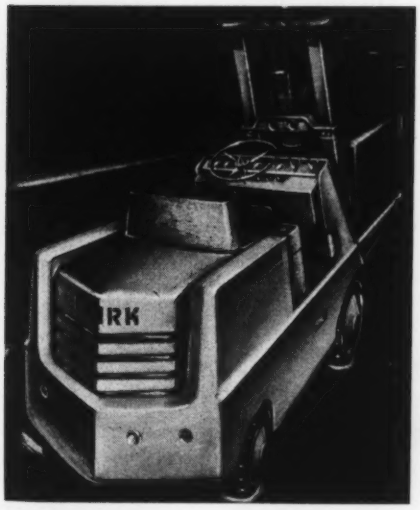
Shown in the photograph, right, is one of the two huge assemblies of welded steel plates that will form the bed of the stretcher. This piece of steel is 138 feet long and weighs 123 tons. When completed, the stretcher will be approximately 180 feet long and 5 feet wide, and will have a total weight of about 2.1 million pounds. It will be capable of handling pieces of metal up to 110 feet in length and of straightening shapes up to 60 square inches in cross-sectional area in 75S alloy, one of the strongest aircraft alloys.

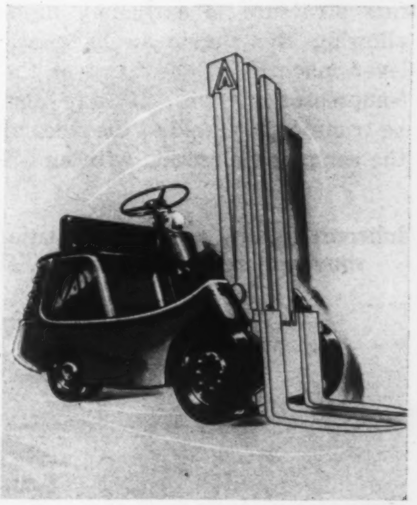


LONG POWER SPRINGS: Spiral wound field telephone retractor springs, shown during inspection at Sandsteel Spring Div., Sandvik Steel Inc., measure 47 feet in length. They are $3/8$-inch wide and 0.042-inch thick. Two springs are mounted on the cable reel of a portable field telephone unit, furnishing the power needed for automatic rewind of the telephone line after use

◆

LIFT TRUCKS OF THE FUTURE: Modern in design as well as functional, these two industrial trucks were introduced at the Fifth National Materials Handling Exposition. American Transportation Company's "Dynamotive" gas-powered truck with electric transmission, right, needs no torque converter, clutch, overdrive mechanisms nor gear shift. The Clark "X-70," left, created to obtain customer reaction to many innovations, will not be produced for sale. One of the features of this truck is its frame, the sides of which turn under between the front and rear wheels to form an oil reservoir on one side and the fuel tank on the other side. The "X-70" also has an automatic transmission and "Hydratork Drive" torque converter which varies torque automatically to compensate for load, grade or speed requirements. Direction can be changed without bringing the truck to a complete stop. A two-way radio is built in



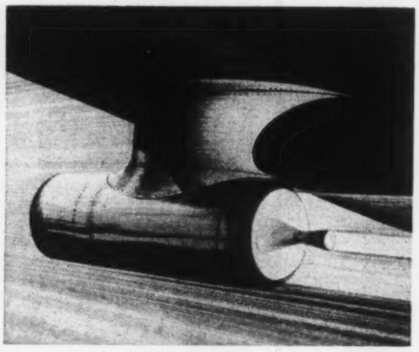


Jet Engine Is Small but Powerful

A compact, cylindrical power package 72 inches long and 22 inches in diameter is said to be the most powerful engine of its size in production today. This is the Fairchild J-44 jet engine, which weighs only 300 pounds and delivers 1000 pounds of thrust. The J-44 is used to power the Ryan "Firebee."

The outer sheet metal covering forms both a pressure chamber and a frame structure joining the two main bearing supports. Heavy castings and framework are, therefore, eliminated for much of the length of the engine. Rigidity of this structure is extremely high, allowing the engine to be cantilever mounted at the front of the compressor section. It may also be trunnion mounted at the sides of the compressor section with an aft stabilizer at the rear bearing support. This method could be used to mount the engine under a transport airplane wing as a pod unit. When mounted in this manner, the smooth outer shell of the unit would eliminate the need for any additional cowling or fairing in most installations.

Fitting sheet metal outer covering of J-44 jet engine. Covering serves as both pressure chamber and frame structure



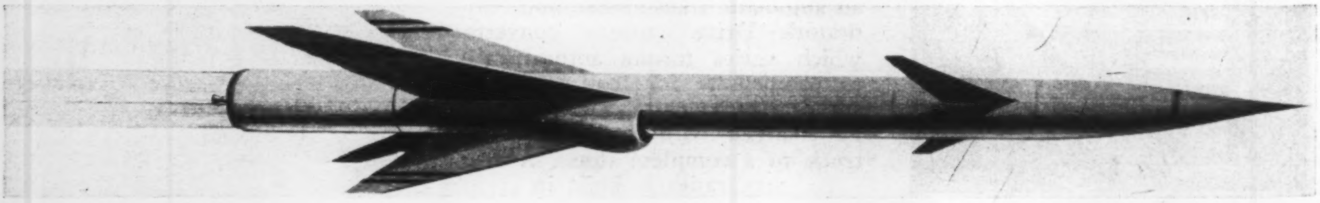
Trunnion-mounted J-44 could boost transport plane payload and reduce operating costs. Design requires few connections to transport airframe

Designed to be a self-contained power plant, the J-44 requires minimum service from the airframe. No external oil coolers or lines are required. Internal oil capacity for 10 hours of operation can be provided. All essential controls, fuel pump and electrical units, including a starter-generator, are fitted on a removable accessory section.

Quickly removable accessory section incorporates all controls, and can be removed by one man

Servicing requires only a few dollars' worth of conventional tools, obtainable in any hardware store. Major repairs, such as replacing front or rear bearings, can be made without engine removal, if the installation provides the necessary access.

Inherent rigidity permits installation of J-44 engine with no aft support, as shown in artist's sketch below. This method is used on Ryan "Firebee"

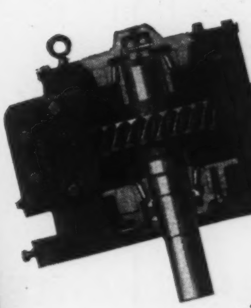


Will Preview Effects of Atomic Energy on Products

Effects of atomic energy on products and production methods will be previewed at the first Conference of Basic Materials, being held concurrently with the Exposition of Basic Materials for Industry in New York, June 15-19. Uses of atomic energy in the next five years will receive particular attention, for radioactive materials and atomic energy are expected to exert profound influence in American industry during that period.

Among problems to be considered are the use of atomic energy for power plants, uses of radioactive materials for testing purposes and investigating properties of other materials, and the effect which the availability of radioactive materials will have on the selection of materials in general. Production problems, including the selection of containers for radioactive materials and cooling methods, also will be considered.

Estimates indicate that a manufacturer has more than 25,000 different materials from which to choose when designing a new product. Selection will be complicated with the introduction of radioactivity, since this factor will not only make many new materials available but will also require development of radioactive-resistant materials.



The Cleveland ND unit, cut away to show tapered roller bearings on gear shaft, positive face-type oil seal, piston type lubricating pump and oil drain at base of housing.

At left—Cleveland size 50 ND unit on pressure mixing tank built by C. E. Howard Corporation, South Gate, Calif.

Space-saving ND unit mixes medicines smoothly

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The ND drive shown here and its companion NU unit (drive shaft upward) are available in seven sizes each. For complete descriptions, capacity charts and other engineering data on these space-saving, powerful Clevelands, write today for free new Catalog 400. The Cleveland Worm & Gear Company, 3265 East 80th Street, Cleveland 4, Ohio.

Affiliate: The Farval Corporation, Centralized Systems of Lubrication. In Canada: Peacock Brothers Limited.

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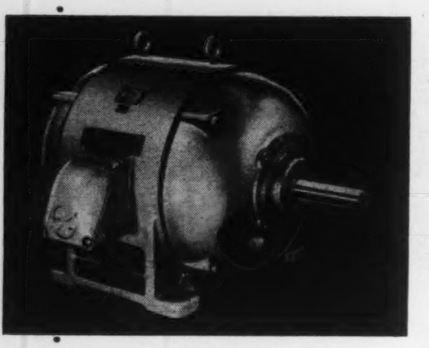

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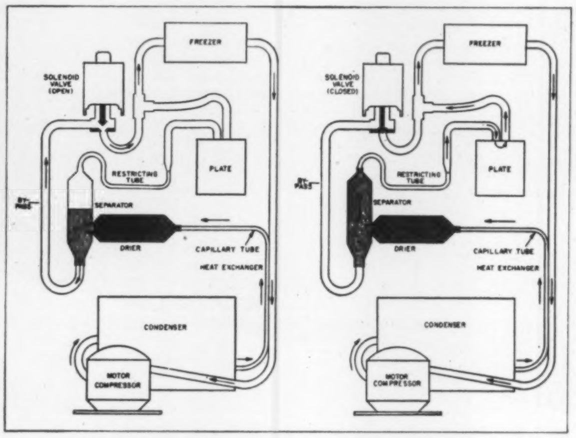
Engineering News

Refrigerating System Maintains Two Temperatures

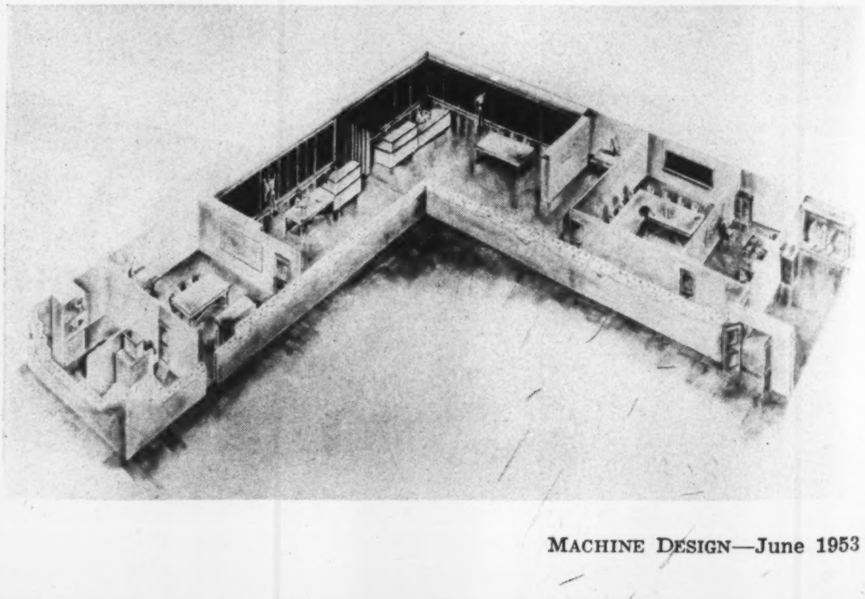
The refrigerating system used in a new, fully automatic Philco home refrigerator maintains the temperature in the food storage compartment at 38 to 42 F while keeping temperature in the freezer between zero and minus 20 F. Two separately controlled heat-absorbing, or cooling, devices are used; one is the conventional evaporator in the freezer, the other is a cooling plate at the rear of the food compartment. Complete sealing of the freezer from the food compartment prevents the temperature in one compartment from affecting that of the other.

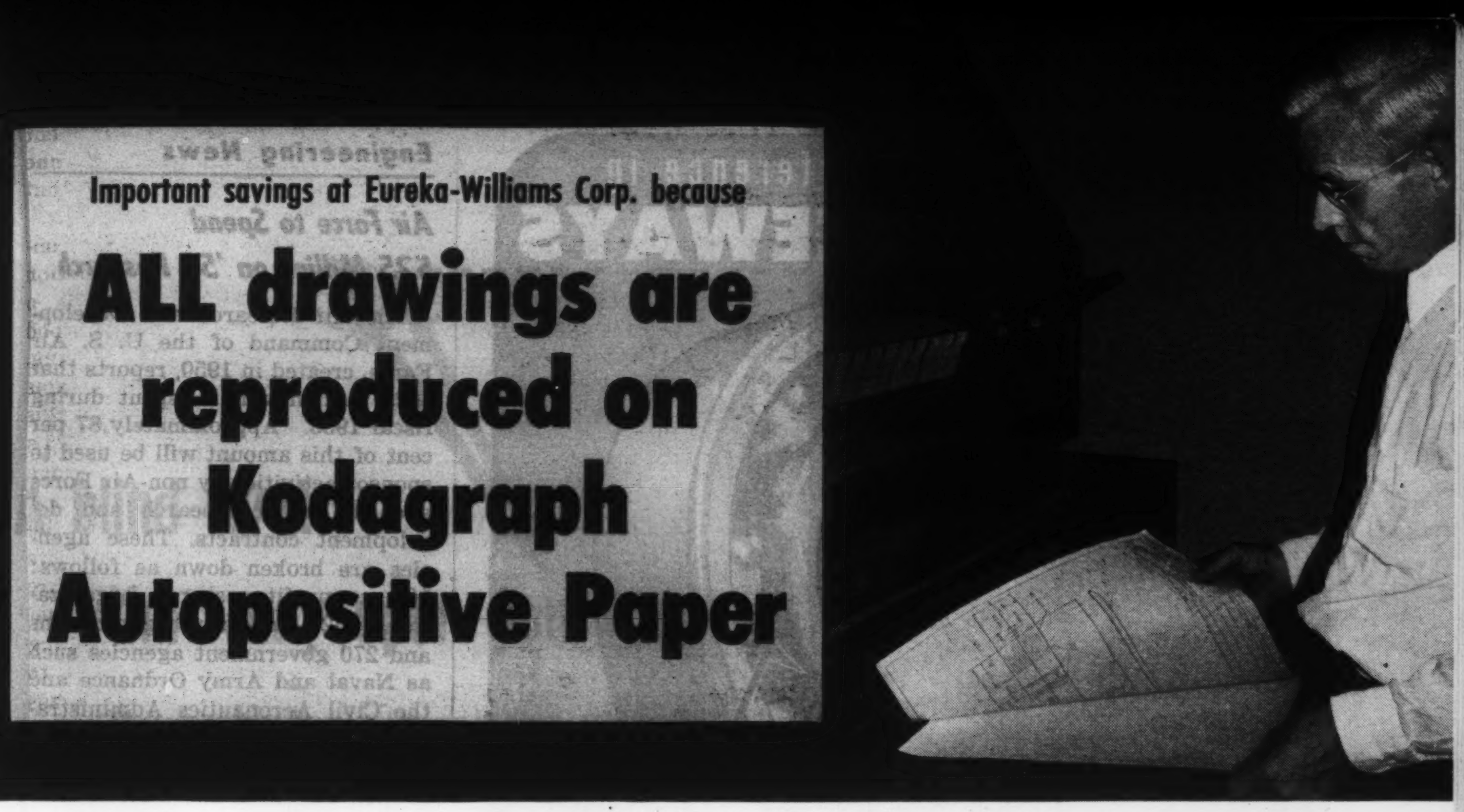


A thermostat in the freezer controls motor-compressor operation and freezer temperature while a separate thermostat in the food compartment controls food cooling. The accompanying flow diagrams illustrate the manner in which this dual cooling is achieved with one compressor-condenser system. When the cooling plate is at its highest temperature the thermostat contacts open, allowing the solenoid valve to close the by-pass around the plate refrigerant circuit (right-hand sketch in flow diagram). Refrigerant then flows through both cooling plate and freezer. When the plate temperature reaches the low regulated temperature value, plate contacts close and the solenoid valve opens. Refrigerant then flows through the by-pass tube to the freezer rather than flowing through the cooling plate, as shown in the left-hand sketch.

◆

POWER SYSTEMS ANALYZER: A miniature ac power distribution system complete with generating stations, transmission lines, transformers, loads and capacitors is being constructed at the Franklin Institute. Financed by seven Middle-Atlantic power and light companies, the analyzer is expected to help them in planning and also solve operational problems, as existing systems or planned systems can be simulated and analysis of operating problems quickly made. The artist's sketch shows what the analyzer will probably look like when finished in 1954





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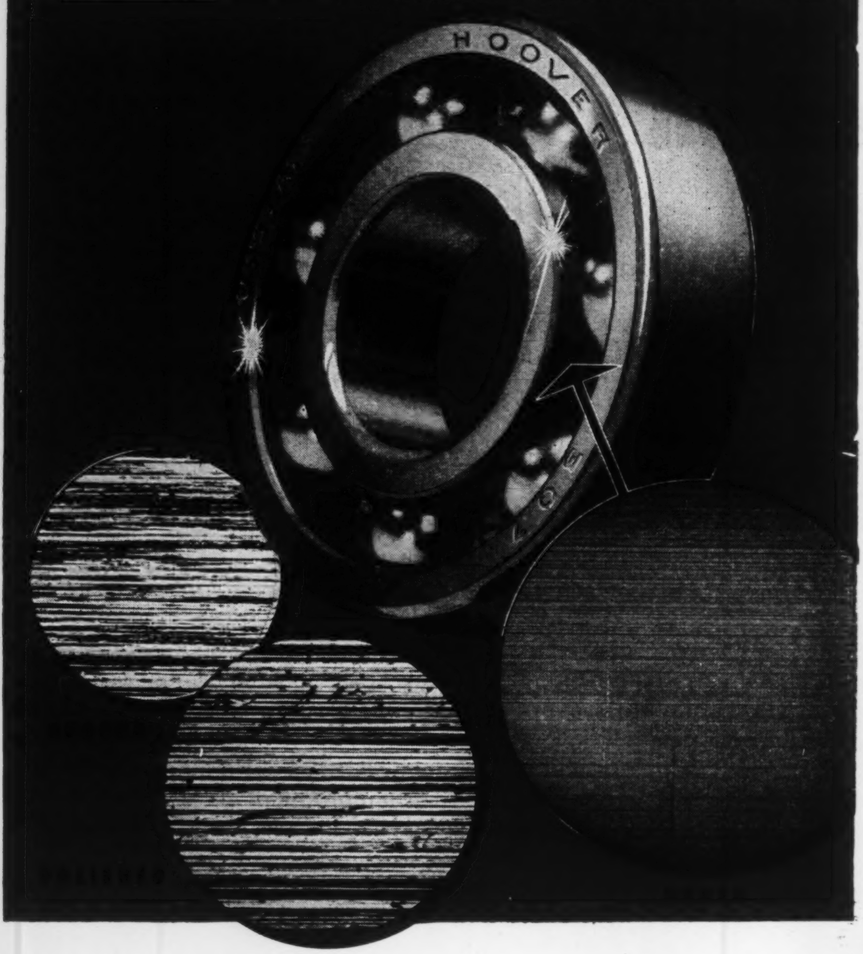
EASTMAN KODAK COMPANY,
Industrial Photographic Division, Rochester 4, N. Y.

Gentlemen: Please send me a free copy of your new illustrated booklet, "New Short Cuts and Savings."

Name________________ Position____________
Company________________
Street________________
City__________ Zone_____ State________

Kodak
TRADE-MARK

You can see the difference in
HONED RACEWAYS



exclusive with
HOOVER BALL BEARINGS

The photographs reproduced above are magnified one hundred times so you can see the difference between ground, polished and honed raceways. The process and the special machines for the honing operation are exclusive, patented, Hoover developments. Honing by Hoover goes far beyond grinding and polishing to achieve a surface that assures amazing quietness plus *longer bearing life . . . and greater load capacity.* That's why Hoover Ball Bearings are the choice of distinguished American manufacturers of fine machines and equipment.

The Hoover Engineering Manual will be mailed free to engineering and purchasing executives requesting a copy on their business letterhead.

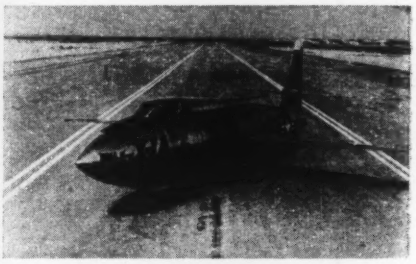
THE ARISTOCRAT OF BEARINGS

HOOVER BALL and BEARING CO.
Ann Arbor, Michigan

Air Force to Spend 525 Million on '53 Research

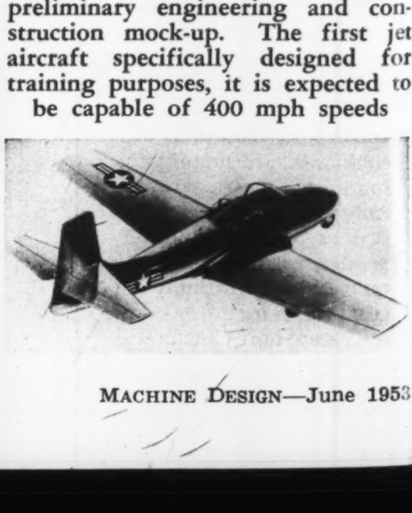
The Air Research and Development Command of the U. S. Air Force, created in 1950, reports that $525 million will be spent during fiscal 1953. Approximately 87 per cent of this amount will be used to sponsor activities by non-Air Force agencies under research and development contracts. These agencies are broken down as follows: 160 nonprofit research organizations, 1520 industrial organizations and 270 government agencies such as Naval and Army Ordnance and the Civil Aeronautics Administration. The remaining 13 per cent of the funds will be used within the Air Research and Development Command's laboratories, primarily to evaluate results of the "outside" developments.

During the year 1952, funds were expended for research in several broad classifications such as aircraft, equipment, electronics, materials, propulsion, human fac-



Bell X-1A, latest in X-1 research aircraft design series, has been prepared for the 1953 flight program. In addition to engineering improvements, it is larger than its predecessor, the X-1

Twin-jet Cessna T-37 is in first phase of development, consisting of preliminary engineering and construction mock-up. The first jet aircraft specifically designed for training purposes, it is expected to be capable of 400 mph speeds



A blind rivet that may open your eyes

There may be a message for you in these pictures, even if you don't use rivets.

For maybe you have a product that isn't performing the way you want it to. And maybe your problem is to find the right metal.

The makers of "pop" rivets had just such a problem.

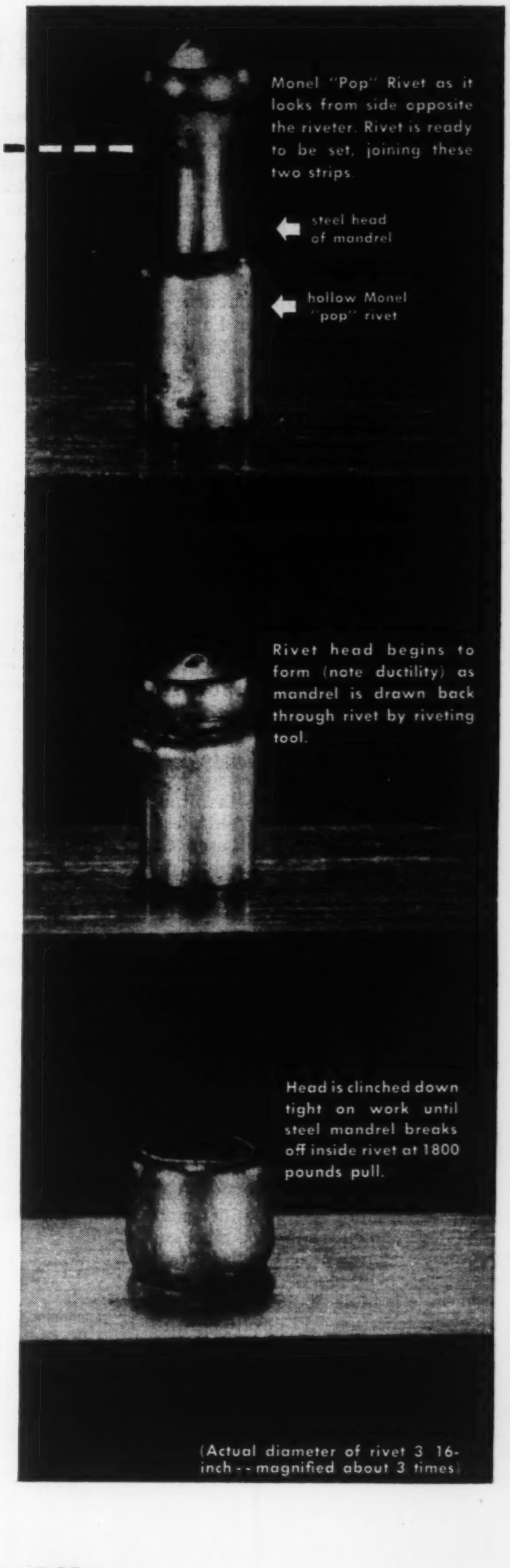
Here they'd come up with a wonderful idea for a blind fastening. The "pop" rivet lets you rivet tightly in blind corners and other confined places where you can only get to work on one side. And it's easy to use and does the job inexpensively. Still, the metal used wasn't quite right for every job . . .

First, they needed a metal that is strong enough to make a tight joint, even in thin gauge sheet metal. Yet the metal had to be ductile enough to form a tight-holding head when riveted. And it had to be able to resist corrosion by most acids, alkalies and many other corrosives.

After trying other metals, they found Monel® provided their answer. And the characteristics and the economy of Monel "pop" rivets make them a possible replacement for many non-blind fastenings as well, wherever a hollow Monel rivet can be used for N.P.A.-approved applications.

Perhaps this metal problem of the rivet makers brings one of your own to mind. And perhaps your solution, too, lies in Monel, or another metal in the Inco Nickel Alloy family. The quickest, easiest way to find out is to write us. All our problem-solving services are yours for the asking. The International Nickel Company, Inc., 67 Wall Street, New York 5, N. Y.

"Pop" Rivets, long known as "Tucker Blind Rivets" in Great Britain, are now being produced in this country by J. C. RHODES & COMPANY, branch of UNITED SHOE MACHINERY CORPORATION, New Bedford, Mass.



Monel "Pop" Rivet as it looks from side opposite the riveter. Rivet is ready to be set, joining these two strips.

Rivet head begins to form (note ductility) as mandrel is drawn back through rivet by riveting tool.

Head is clinched down tight on work until steel mandrel breaks off inside rivet at 1800 pounds pull.

(Actual diameter of rivet 3/16-inch -- magnified about 3 times)

Inco Nickel Alloys

Monel® • "R"® Monel • "K"® Monel • "KR"® Monel • "S"® Monel • Inconel® • Inconel "X"® • Inconel "W"® • Incoloy® • Nimonic® Alloys • Nickel • Low Carbon Nickel • Duranickel®

SMALL STAMPINGS

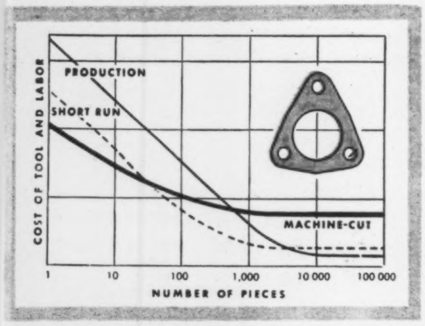
A COST-SAVING, VERSATILE APPROACH TO THEIR MANUFACTURE

Possibly you've always thought that a quick look at the quantity involved decides how a stamping shall be made. Sometimes it is done that way but it isn't the sure way to lowest costs.

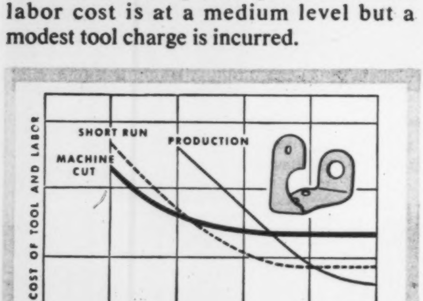
A more scientific approach by the STAMPINGS DIVISION of the Laminated Shim Company in Glenbrook, Connecticut frowns on the term "short run stamping." There is what is known as the short run *method* but there is no definite dividing point between short run and production quantities. Contour, tolerances, material, many other items all affect the manufacturing method when costs are being carefully figured.

NO ONE METHOD IS ALWAYS CHEAPEST; THREE ARE NEEDED

Machine-Cut Method: The STAMPINGS DIVISION goes one step further than Short Run and Production Methods. The Machine-Cut Method, though not strictly a stamping operation is a valuable addition to stamping procedure. Custom built slitters, cutters, saws and files use experience-gained techniques to fashion the smaller quantities of parts. No dies are made; only stock punches are used. Obviously labor cost is understandably high but there is no tool charge.



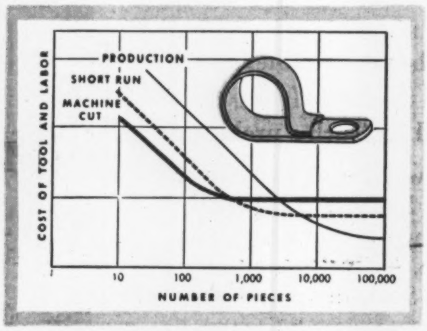
Short Run Method: As quantities increase (and depending upon the complications of contour, material, etc.) the economy of a temporary blanking die must be considered to eliminate the labor expense of machine-cutting. When this point is reached, manufacture is by the Short Run Method and the blanking is supplemented by other bench press operations. Here labor cost is at a medium level but a modest tool charge is incurred.



Production Method: As quantities increase the Production Method using standard dies with high speed automatic presses becomes more attractive. A relatively high tool charge can then be amortized over a great number of parts. Labor charge is negligible.

The Production Method as developed by the STAMPINGS DIVISION is offering unusual cost saving possibilities because of the new low-cost, full service Hecht-type die developed by the company for certain applications.

It is interesting to note that sometimes a very small quantity of parts would require a standard die because of complications or close tolerances or tough materials involved. Thus occasionally a very small quantity goes into the production classification.



LOWEST COST IS ASSURED WHEN SUPPLIER HAS ALL THREE METHODS

The illustrations show typical stamped parts along with relative costs and breaking points for each of the three manufacturing methods. Unless a supplier can offer all three, his costs cannot always be low. For a given quantity, only *one* method can be most economical.

ONE OR ONE MILLION PARTS FROM SAME SUPPLIER

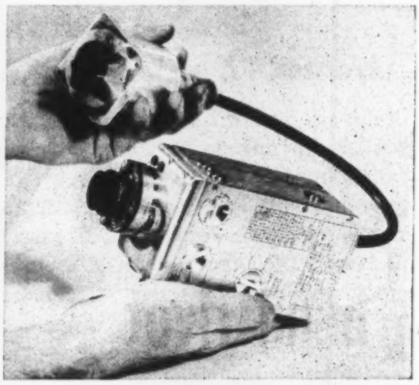
An important corollary to the above is that an experimental part in small quantities can be handled by the same supplier when full production quantities are needed

Further, it is important that a supplier be fully informed, if possible, on later or total requirements for a given part. As the charts point out, such information will affect manufacturing method and make possible cost reductions.

FURTHER INFORMATION AVAILABLE

An illustrated 12 page brochure describing in greater detail the methods mentioned above is available on request to the
STAMPINGS DIVISION
Laminated Shim Company, Inc.
1206 Union Street, Glenbrook, Conn.

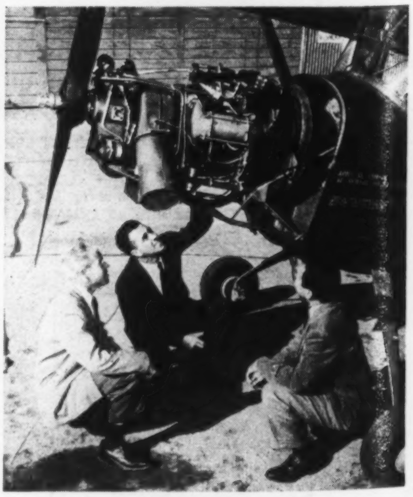
Engineering News



The N-9 recording camera, developed by Bolsey Ltd. for the Air Force, can be synchronized to the firing mechanism of high-speed jet combat aircraft. Operating at speeds up to 64 frames per second, it can freeze action at velocities of more than 1300 mph

tors (including aeromedicine), and Geophysics. Four examples of the hundreds of projects are the Bell-X-1A rocket powered research plane, a turboprop engine for light aircraft, the Cessna T-37 twin-jet trainer and an aerial "gun" camera which can freeze the action of jet planes moving at relative speeds of more than 1300 mph. These developments are shown in the accompanying photographs.

Developed by the Air Force, Cessna, Boeing and the Navy to meet Army field forces requirements, the Cessna XL-19B is the world's first turboprop light plane. First flight was made in November, 1952. The turbine is said to eliminate cooling problems and virtually all vibration. Fuel may be diesel oil, automotive or aviation gasoline, or jet fuel



Unveil Model of Passenger Conveyor

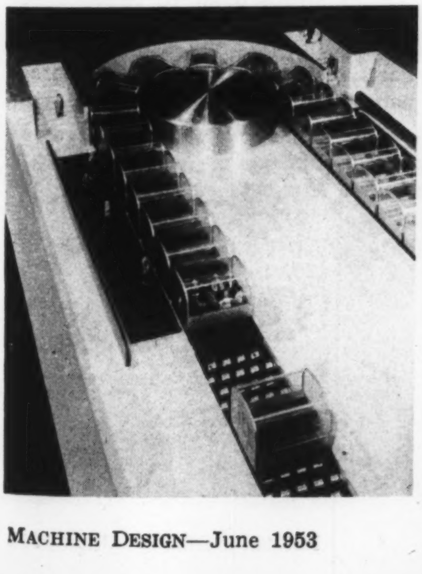
A working 15-foot scale model depicts actual operation of a passenger conveyor system proposed for New York City. This model has moving loading and unloading platforms, deceleration and acceleration systems, main line belts, turn-arounds and "astradome" cars. Earlier plans for this conveyor system were reported in MACHINE DESIGN for October 1952, page 245.

Designed by Goodyear Tire & Rubber Co. engineers in co-operation with engineers of Stephens-Adamson Mfg. Co., the "continuous flow transit system" is proposed for use as a Grand Central - Times Square shuttle.

In operation, passengers at either end of the subway would walk directly onto the 9-foot wide loading platform, which moves at the rate of 1½ miles per hour. Nineteen cars, each of which seats 14 passengers, pass the loading platform each minute, also traveling at the rate of 1½ miles per hour. Leaving the loading area, the cars pass over rows of pneumatic-tired accelerating rollers. Each row of wheels moves slightly faster than the previous row, so that the car is uniformly accelerated to 15 miles per hour. Speed is decreased at the other end of the system by a similar method.

Capacity is 32,000 persons an

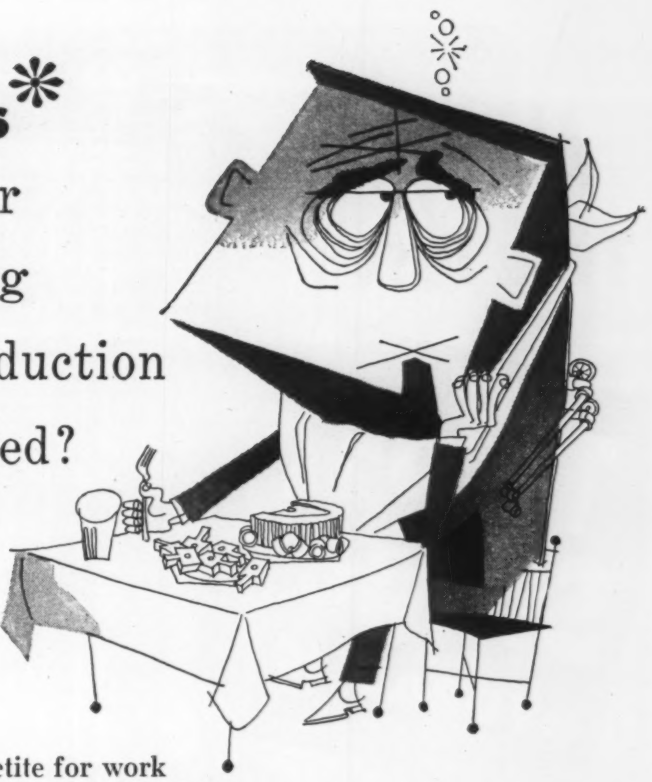
Working model of passenger belt subway system shows loading and accelerating methods



does

coil-itis*

have your processing tank production off its feed?



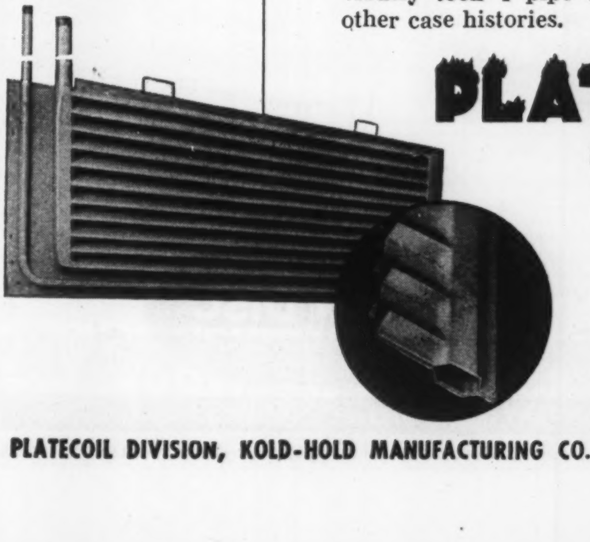
When the appetite for work of your heating and cooling processes diminishes, the trouble may well be coil-itis. For, downtime due to pipe failures and limitations can seriously delay your production flow. Switch to Platecoils, the new tonic for production, as revolutionary as the new wonder drugs. Platecoils take 50% less tank space leaving more room for greater payload. They heat or cool 50% faster. They simplify maintenance and save hours of downtime. Equally important, Platecoils cost as much as 50% less in the first place. Platecoils cure production troubles involving heat transfer and give production a shot in the arm.

Write for Bulletin P71 today!

PLATECOILS SAVE 50% IN HEAT TRANSFER COSTS

PLATECOILS ELIMINATE A 6-TO-8 HOUR-A-DAY CHIPPING JOB

At Sealed Power Corp., installation of Platecoils has completely eliminated a 6-to-8 hour-a-day chipping job. Three Platecoils now heat a tank that previously took 4 pipe coils. Ask about other case histories.



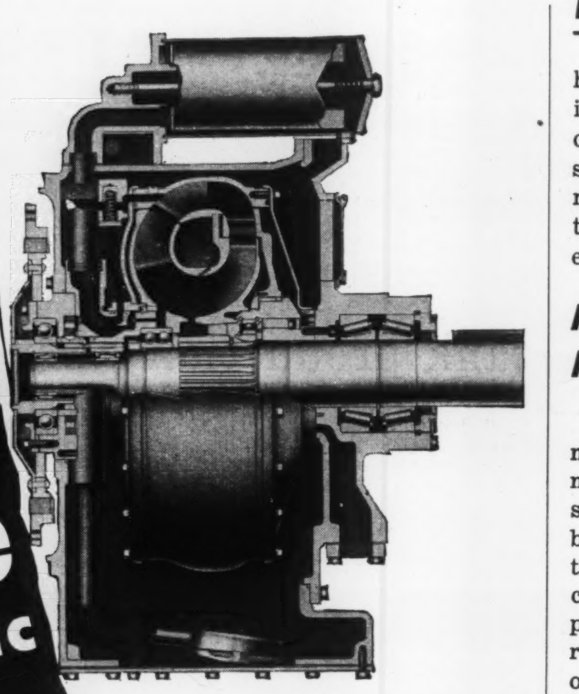
PLATECOIL

REPLACES PIPE COILS

*Coil-itis — Diagnosed as tank heating and cooling problems. Platecoils — the prescription for solving pipe coil problems.

PLATECOIL DIVISION, KOLD-HOLD MANUFACTURING CO., LANSING 4, MICHIGAN

NEW
TWIN DISC
Two-Stage
HYDRAULIC
TORQUE CONVERTER

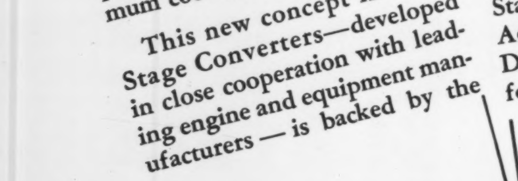


Filling the gap in industrial hydraulic drives, Twin Disc offers the first of a new series of Two-Stage Hydraulic Torque Converters — providing maximum operational efficiency, *up-to-4:1 torque multiplication at stall* combined with *progressively* increasing engine speed during acceleration or *uniform* pull-down under load. This new series features complete unloading of the engine at high-speed, no-load conditions, providing economy and minimum cooling requirements.

This new concept in Two-Stage Converters—developed in close cooperation with leading engine and equipment manufacturers — is backed by the same engineering and service reputation that has already made Twin Disc the acknowledged world leader in the development of Industrial Three-Stage Hydraulic Torque Converters.

If you are using powered equipment needing a Torque Converter Drive — and for which the modified performance characteristics indicated are desirable—write for specific information on the new Two-Stage Torque Converter Series. Address all inquiries to Twin Disc Hydraulic Division, Rockford, Illinois.

Typical Twin Disc Two-Stage Hydraulic Torque Converter, Model SD (shown above), with Spider Drive and Disconnecting feature.



TWIN DISC
CLUTCHES AND HYDRAULIC DRIVES

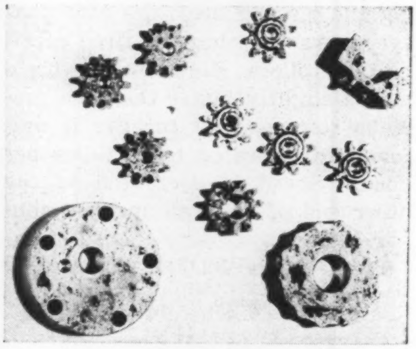
TWIN DISC CLUTCH COMPANY, Racine, Wisconsin • HYDRAULIC DIVISION, Rockford, Illinois
BRANCHES: CLEVELAND • DALLAS • DETROIT • LOS ANGELES • NEWARK • NEW ORLEANS • SEATTLE • TULSA

hour, compared with 23,000 an hour in the present subway shuttle. Cost of the conveyor equipment, installed in existing tunnels, is estimated at less than 60 per cent of the cost of conventional subway equipment.

Impregnating Process Assures Nonporous Powder Metal Parts

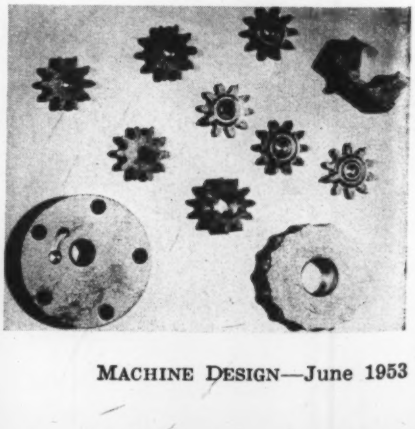
Through use of a new impregnating process, porosity of powder metal parts can be eliminated and such parts can be plated. Developed by American Metaseal Mfg. Corp., the new process employs a solid copolymer which completely and permanently fills all pores. Excess resin is removed from the outside of the parts with an emulsion type cleaner that does not attack the impregnant. To remove excess plastic from part surfaces, early types of plastic impregnants required a solvent which also removed the impregnant from the pores.

In the new process, parts are

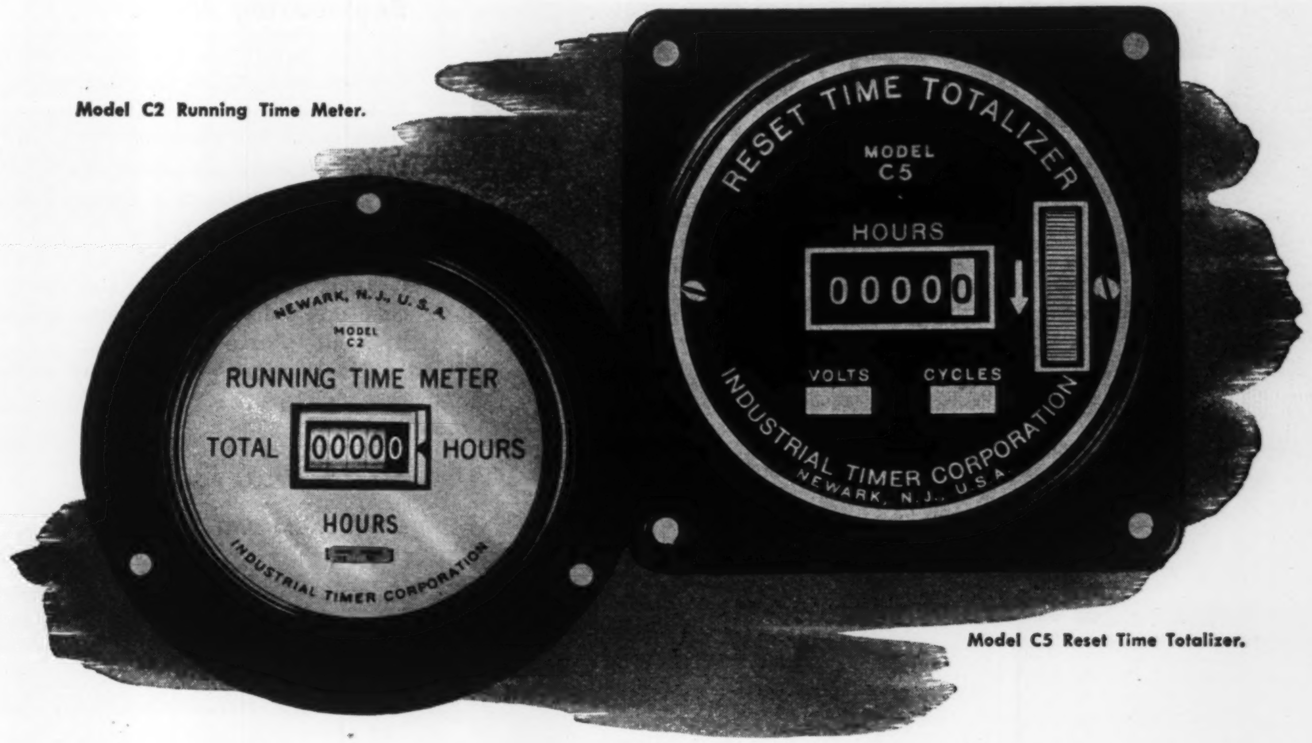


Pinion gears and other parts plated in the ordinary manner show corrosion after 10 days

Parts sealed with polyester impregnant before plating show no corrosion after 5 months



Model C2 Running Time Meter.



Model C5 Reset Time Totalizer.

NOW BOTH! Reset and Non-Reset Elapsed Time Meters

For applications where it may be desirable to reset to zero at any time, Industrial Timer now offers Reset Time Totalizers, in addition to its Running Time Meters.

SYNCHRONOUS MOTOR DRIVEN. Both types of elapsed time meters provide you with an exact record of machine hours on A.C. operated machines... up to 100,000 hours with "electric clock" running accuracy. Both utilize heavy duty synchronous motors that are self lubricating for long life. And both are available in enclosed and open type models. Running Time Meters are enclosed in black bakelite cases. Reset Time Totalizers in steel housings with baked black finish.

WIDE VARIETY OF APPLICATIONS. These Industrial Elapsed Time Meters permit you to compute readily production costs on A.C. operated machines — predict replacements for equipment of predetermined life expectancy. They can be used in a wide variety of applications such as: radio transmitters, vacuum tube devices, refrigerators, oil burners, molding machines, life test equipment, diesel generators, conveyors and many other types of machinery and equipment. For technical data, request Bulletin 88-53.

Reset Time Totalizer — Model Designations

CASED	OPEN	COUNT	RANGE	VOLTAGES	CYCLES
C 5		1/10 hr.	10,000 hrs.	115,220	60,50,25
	C 7	1/10 hr.	10,000 hrs.	115	60,50,25
C 5A		1 hr.	100,000 hrs.	115,220	60,50,25
	C 7A	1 hr.	100,000 hrs.	115	60,50,25

Running Time Meters — Model Designations

CASED	OPEN	COUNT	RANGE	VOLTAGES	CYCLES
C 2		1/10 hr.	10,000 hrs.	115,220,440	60,50,25
	C 4	1/10 hr.	10,000 hrs.	115	60,50,25
C 2A		1 hr.	100,000 hrs.	115,220,440	60,50,25
	C 4A	1 hr.	100,000 hrs.	115	60,50,25
C 2D		1/10 min.	10,000 min.	115,220,440	60,50,25
	C 4D	1/10 min.	10,000 min.	115	60,50,25
C 2F		1 min.	100,000 min.	115,220,440	60,50,25
	C 4F	1 min.	100,000 min.	115	60,50,25

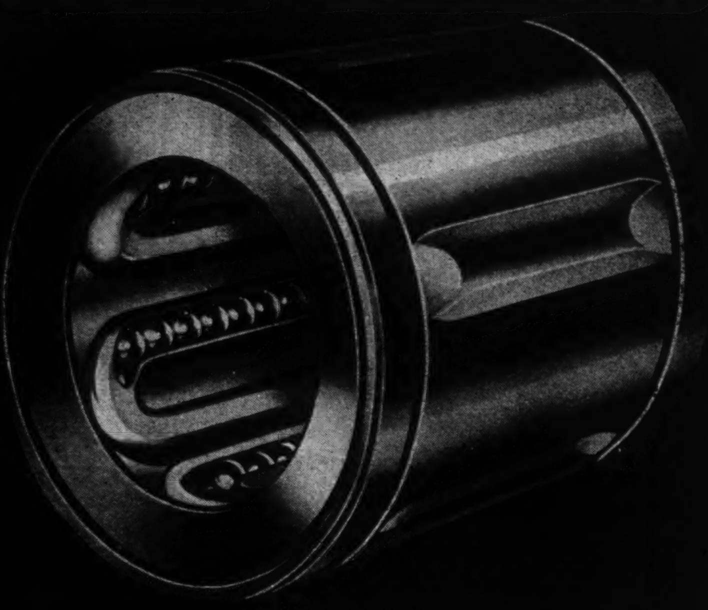
MANUFACTURERS OF THESE AND OTHER TIMERS AND CONTROLS FOR INDUSTRY —
CAM TIMERS • TIME DELAY TIMERS • AUTOMATIC RECYCLING TIMERS
MANUAL SET TIMERS • INSTANTANEOUS RESET TIMERS.

Timers that Control
the Pulse Beat of Industry

INDUSTRIAL TIMER CORPORATION

INDUSTRIAL TIMER CORPORATION
115 EDISON PLACE, NEWARK 5, N. J.

BALL BUSHING



The BALL BEARING for your

LINEAR MOTIONS

Sliding linear motions are nearly always troublesome. Thousands of progressive engineers have solved this problem by application of the Precision Series A or Low-Cost Series B BALL BUSHINGS.

Alert designers can now make tremendous improvements in their products by using BALL BUSHINGS on guide rods, reciprocating shafts, push-pull actions, or for support of any mechanism that is moved or shifted in a straight line.

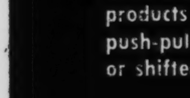
Improve your product. Up-date your design and performance with BALL BUSHINGS!

Now manufactured for 1/4", 1/2", 3/4", 1", 1 1/2" and 2 1/2" shaft diameters.

LOW FRICTION • LOW MAINTENANCE
ELIMINATES BINDING AND CHATTER
SOLVES SLIDING LUBRICATION PROBLEMS
LONG LIFE • LASTING ALIGNMENT

Progressive Manufacturers Use Ball Bushings
—A Major Improvement at a Minor Cost

THOMSON INDUSTRIES, Inc.
Dept. E MANHASSET, NEW YORK



Write for descriptive literature and the name of our representative in your city.

Also manufacturers of NYLINED Bearings — DuPont NYLON within a metal sleeve—for rotation and reciprocation.

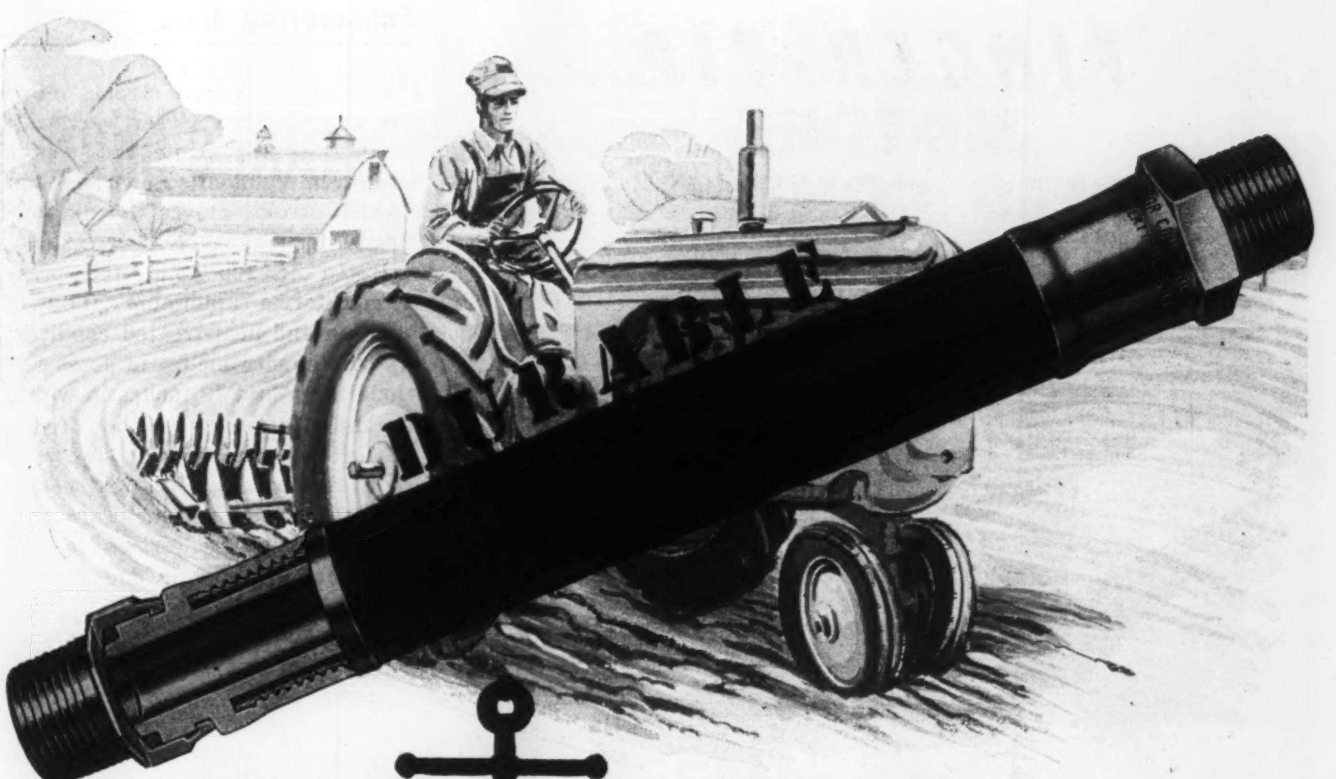
cleaned and dried by degreasing and preheating. Air is removed from pores by vacuum; release of vacuum allows Metaseal 19V5 impregnant to penetrate pores. Positive pressure is applied to assure penetration. Castings are then cleaned, and cured by the Metacure method which converts liquid to solid. Parts are pressure-tight and withstand pressures of more than 5000 psi.

Stretch Press Forms Extrusions and Sheets

Designed for quick and accurate forming of aluminum alloy extrusions and sheets, a new high-production stretch-form press occupies only 25 per cent of the floor area and costs only 20 per cent as much as other machines of this type. Longren Aircraft Co. developed the new Longren-Peterson press, which performs stretch-leveling, preforming, wrapping, skin pressing, bending, forming and stretch-pressing of a wide variety of parts to double curvature.

Operating at 2000 to 3000 psi, the single-action hydraulic system of the press consists of five double-action cylinders, a high-volume pump and pump unit. Two vertical and two horizontal cylinders and a center main-ram cylinder can be used in combination or separately to give the machine flexibility in forming.

Located in the sides of the base, two horizontal cylinders with 30-inch stroke move the chuck support plates horizontally to accommodate parts from 6 inches to 30 feet in length. Two vertical cyl-



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ONE-WIRE BRAID HOSE ASSEMBLIES

for medium-and low-pressure service

Factory-assembled to your specifications—you get just what you need.

Long, uniform, positive grip assured by internally-threaded coupling shell.

Eliminates leaks and blow-offs in medium- and low-pressure service.

Sizes and types for every application — available with solid male or union male ends.

"O" ring seals prevent leakage between swivel ends and the coupling body.

Use of swivel male ends eliminates need for adapter unions, reduces the number of joints, and lets hose assume normal position when pressure is applied to the line.

Exclusive Anchor Max-Flo coupling gives you the equivalent of unrestricted flow through the couplings.

• • •

Get more information. Attach coupon to your letterhead and mail today!

NEW!
REVOLUTIONARY
ANCHOR FLANCO
SPLIT-FLANGE CLAMP

Positive leakproof connection *without* threaded joints. Bolt centers are located to distribute the forces evenly and prevent tilting of the clamp halves. Easy to assemble with small automotive-type wrench.

ANCHOR COUPLING CO. INC.

Main Office and Factory: LIBERTYVILLE, ILLINOIS
FACTORY BRANCHES: DETROIT, MICHIGAN • DALLAS, TEXAS

Anchor Coupling Co. Inc.
Dept. MD63, Libertyville, Illinois
Yes, I'm interested in
☐ Anchor one-wire braid hose assemblies
☐ New Anchor Flanco Split-flange clamp-type coupling
Send me information.

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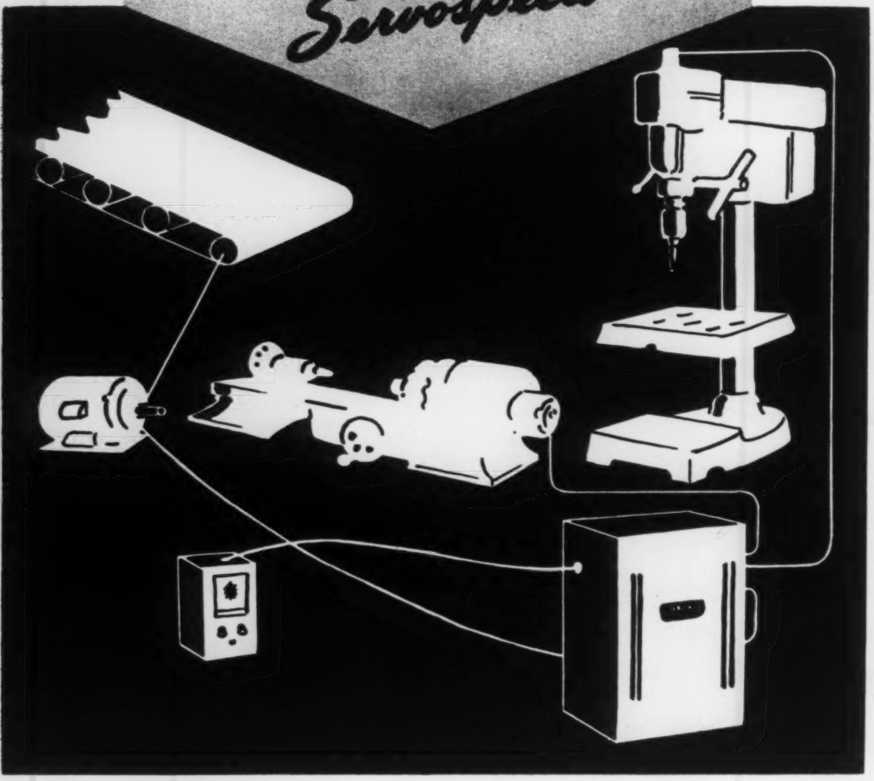
MOTOR
SPEED CONTROL
by
Servospeed



Here's HOW IT WORKS
. . . for Machine tools and
other applications

Modern industrial electronic engineering has been coordinated with electric motor design to provide a versatile means for obtaining the full possible advantage of speed control in DC motors while operated from the regular alternating current power line. Grid controlled "Thyratron" tubes are utilized for power conversion in controlled stepless variation to supply motor armature power. Patented feedback, or "Servo", circuits provide constant torque capability over wide speed ranges of as high as 60 to 1 in some models and a minimum of 20 to 1 in others. Speed changes may be made while in operation from points remote to the motor installation. Standard models in ratings up to and including 3 horsepower are available for prompt delivery.

Your application problems for manual or automatic models will receive the prompt attention of our sales engineers.

Servospeed
DIV. of ELECTRO DEVICES, Inc.
4 Godwin Ave. Paterson, N. J.

inders, with 24-inch stroke, move the gripper jaws either vertically or horizontally, and the center main-ram cylinder, which has an 18-inch stroke, moves the die vertically.

Rated at 100 tons, the press stretch-forms aluminum alloy in solution and heat-treated condition up to 3 square inches in cross-sectional area and 72 inches in width. Contour forming can be accomplished on extrusions or sheets up to 16 feet in length and extrusions up to 6 inches in width.

Material to be formed is laid over the forming die and gripped by chucks. The die can then be made to ascend or descend vertically, and the chucks can move horizontally, either closer together or farther apart, so that the material is stretched over the die beyond its elastic limit until it assumes the shape of the die. Parts are formed without springback, and hand finishing is not required.

Loudspeaker Powers Resonant Vibration Calibrator

An ordinary eight-inch loudspeaker is used to excite a system of mechanically resonant beams in a vibration calibrator constructed at the National Bureau of Standards. The device is used for calibrating moving-coil type velocity gages over a frequency range of 10 to 250 cps at displacement amplitudes of as little as 50 microinches. Pure wave form and simplicity and economy of production are combined in the instrument. The transducer being calibrated is rigidly fastened to the mechanical system, and the amplitude of vibration is observed optically with respect to a point in space.

Two parallel plates of high-strength aluminum alloy or medium carbon steel, about 18 inches long, are the resonant beams. Plates used are about 2½ inches wide and vary from 1/16 to ¼-inch thick. Variations in thickness and material produce different resonant frequencies; however, a single set of beams is used for a frequency range from about 50 per cent to 150 per cent

(*Continued on Page* 264)

Build a Better Motor...

WITH CDF

MICABOND

TAPES, SHEETS, SEGMENTS, TUBING, "V" RINGS

TO WORK WITH YOUR PRODUCTION PEOPLE our large, progressive company has special know-how on planning and producing superior mica insulation. Making exactly what you want, when you want it, is a routine part of your C-D-F Micabond purchase. If you need a new source for mica, the C-D-F Valparaiso, Indiana plant can be the answer.

TO SUPPLY YOUR PRODUCTION NEEDS C-D-F's skilled mica workers run precision machinery developed to make Micabond products uniform in their mechanical and electrical properties. A vigorous research and quality control program gives you facts and proven materials for high-heat motor applications.

ALWAYS SPECIFY MICABOND but talk over your insulation requirements with your C-D-F sales engineer. To build a better motor, to get more insulation value, put C-D-F experience to work for you. *America's largest users of mica products rely on C-D-F.* Samples of Micabond materials, technical aid, all are yours on request.

THE NAME TO REMEMBER... CDF MICABOND

Continental-Diamond Fibre Company

NEWARK 15, DELAWARE

This cork-and-rubber tape protects TV picture tubes

For cushioning TV picture tubes, or any fragile parts that contact metal or wood, there's nothing quite like Armstrong's resilient DK-153 Tape.

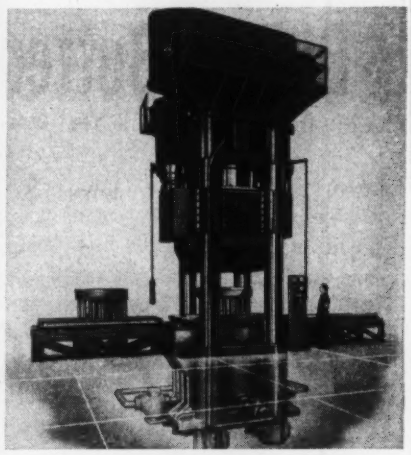
The tape's resilient cork-and-rubber composition absorbs shocks and damps vibrations. Its soft surface won't scratch, so you can use the tape against polished wood or metal surfaces as well as glass.

DK-153 is fast and easy to apply. Just peel off the cloth backing and press the tape into place. The pressure-sensitive adhesive on the back grips instantly.

You can get Armstrong's DK-153 Tape in a variety of widths and thicknesses in sheets, rolls, tapes, or die-cut shapes. For samples, write on your letterhead to Armstrong Cork Company, Industrial Division,
7306 Dean Street,
Lancaster, Penna.
Available for export.

ARMSTRONG'S
DK-153 TAPE

Cork-and-rubber
Tacky adhesive
Protective backing



Artist's conception of press for new Hidraw method of deep drawing

sign features to the press to incorporate the Guerin and die quenching operations.

Advantages claimed for the Hidraw process are:

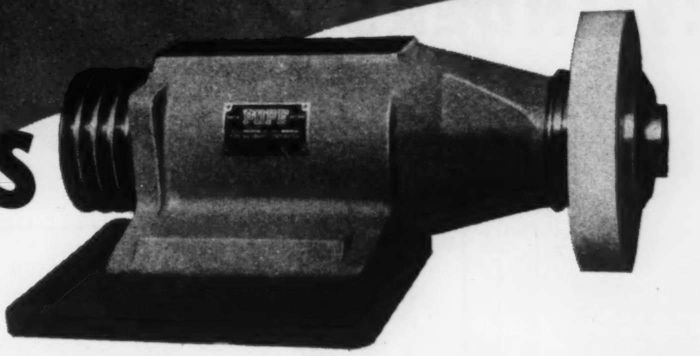
1. Perfect surface finish of part, inasmuch as the part is in contact with rubber and male portion of die only while draw operation is being performed
2. Uniform thickness and minimum stretching, because the part is formed by fluid pressure and is not subjected to an ironing operation
3. Forming difficult contoured parts straight from the blank to finish, since the rubber acts as a fluid pressure medium and no unsupported metal is between the point of contact with the punch and the draw ring
4. Inexpensive tooling, especially for thousands of parts and small production lots
5. Elimination of hand work in removing wrinkles encountered in the Guerin operation.

In addition, parts usually produced by the drop hammer method can be produced by unskilled operators with the Hidraw process.

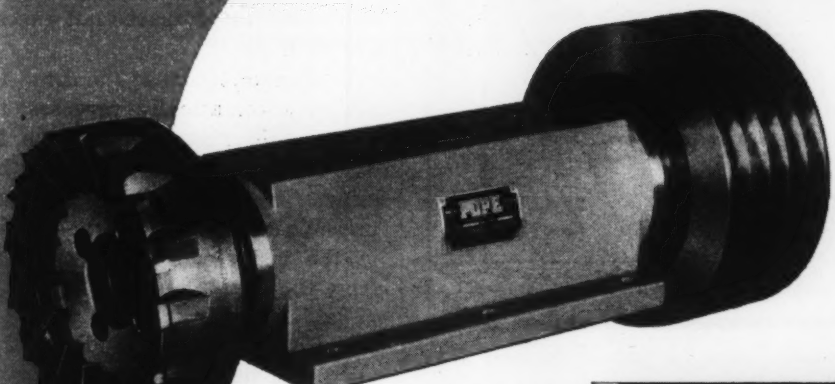
At the start of the draw, a blank is placed on the blankholder plate, which is flush with the top of the punch. The main platen descends to the work, slowing down automatically at the point of contact to prevent deforming the blank by high-speed contact. The platen then continues to descend, generating pressure in the rubber pad which grips the blank between the face of the pad and the blankholder ring. Pressure generated in the pad is determined by the pressure de-

Specify POPE

HEAVY DUTY WHEEL HEADS



"A"

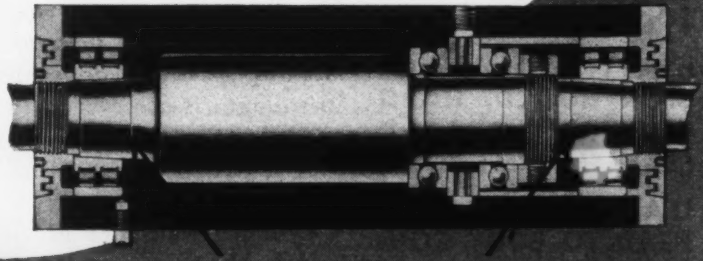


"B"
Power-Max 25 HP

Note the big precision bearings and the big shaft.

A pair of precision thrust bearings stabilize the shaft against any axial movement in either direction. (No end play)

The double row cylindrical roller bearings carry the radial loads with ease and at low temperature.



Taper mounting provides for precise individual preloading of the radial bearings.

Send us your specifications and ask for Catalog No. 59.

POPE Heavy Duty Wheel-Head Spindles are designed for a wide variety of applications such as grinding, boring, milling, drilling and many other operations requiring PRECISION COMBINED WITH RUGGEDNESS in the spindles.

For continuous production and trouble-free operation THERE'S NOTHING LIKE A POPE SPINDLE WITH ROLLER BEARINGS.

No. 94

Specify **POPE**
PRECISION SPINDLES

POPE MACHINERY CORPORATION
Established 1920
261 RIVER STREET HAVERHILL, MASSACHUSETTS

veloped in the hydraulic cushion in the press bed, which in turn supports the blankholder ring on pins extending through the press bolster plate.

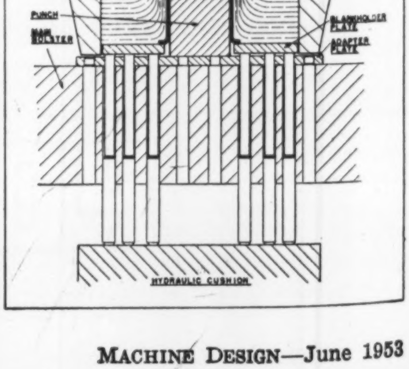
Pressure generated in the rubber pad forces the blank down over the punch, and at the same time the blank is clamped between the surface of the rubber pad and the blankholder ring, preventing the formation of wrinkles. The rubber acts as a fluid pressure, insuring conformity of the drawn part to the contour of the punch. Rubber pressures ranging from 4000 to 10,000 psi have been employed by the process. High-tensile alloys and stainless steel require high pressure; however, 90 to 95 per cent of present-day aircraft parts can be formed at pressures not exceeding 6000 psi.

Upon completion of the draw, the platen automatically reverses, the blankholder ring remaining in the down position until the pad has cleared the drawn part. Pullback pressure applied to the die cushion in the bed ejects the drawn part from the punch.

Tables are available with two and four stations, and multiple parts can be drawn if they are approximately the same depth.

In designing presses for Hidraw operation, Hydraulic Press engineers endeavored to produce a general purpose machine which may be used for the Hidraw operation, the Guerin operation, and matching male and female die setups with integrated control of pressing speed and cushion pressure as required. Further adaptations to the presses

Part completely formed by pressure of the rubber pad around punch



CIRCULAR HEADS WITH TIE RODS
SQUARE HEADS WITH TIE RODS
SPACE SAVED
T-J SPACEMAKER . . . provides additional room for adjacent equipment without sacrificing strength.

NEW T-J Spacemaker AIR CYLINDERS

- SAVES UP TO 40% SPACE WITH NEW STREAMLINED DESIGN.
- SUPER STRENGTH . . . EXTRA HIGH SAFETY FACTOR.
- SOLID STEEL HEADS.
- HEAVY WALL, PRECISION HONED, HARD CHROME PLATED SEAMLESS STEEL BODY.
- LEAKPROOF CYLINDER HEAD TO BODY CONSTRUCTION.
- RELATIVE PORT POSITIONS MAY BE ROTATED WITHOUT DISASSEMBLY OF CYLINDER AND LOCKED IN DESIRED POSITION.
- HEAVY DUTY, HI- TENSILE, HARD CHROME PLATED PISTON ROD.

Streamlined construction of the new T-J Cylinders *eliminates tie rods . . . reduces head size . . .* and *saves up to 40% in mounting space!* In addition, a new high in strength is achieved with solid steel heads and heavy wall seamless steel body . . . leakproof construction . . . extra high safety factor.

Cylinder walls are precision honed and hard chrome plated for long-life efficiency. Available with the new T-J Super Cushion Flexible Seals which insure positive cushion with automatic valve action for fast return stroke. Many standard sizes and styles . . . both cushioned and non-cushioned . . . for wide range of pushing, pulling, lifting, clamping or control jobs. T-J dependability. *Fast delivery* to meet rush requirements. Write for bulletin 8152. The Tomkins-Johnson Co., Jackson, Mich.

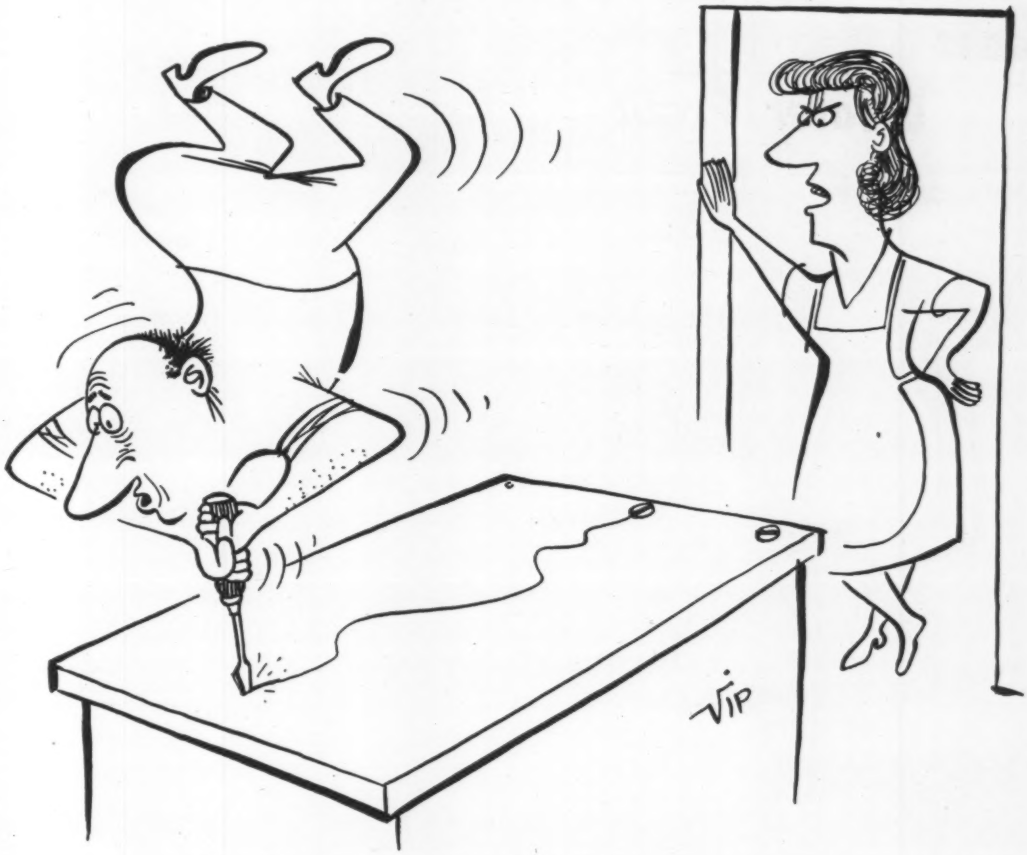
Many More Advanced Features!

37 YEARS EXPERIENCE

T-J TOMKINS-JOHNSON

RIVITORS AIR AND HYDRAULIC CYLINDERS CUTTERS CLINCHORS

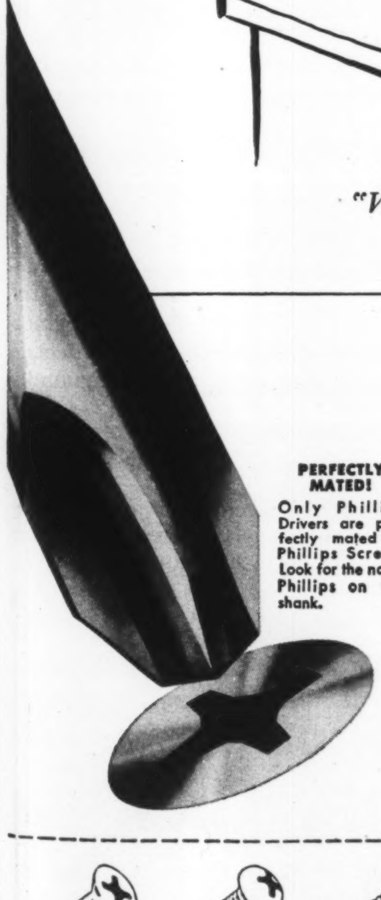
What's Screwy? *by Phillips*



"Very fancy, dear, but wouldn't it be cheaper to use Phillips Cross-Recessed-Head Screws?"

FREEDOM FROM DRIVER SKIDS is just one of the advantages of Phillips Screws. No danger of marring the finish. In addition, they drive in much faster. And they add to the structural strength of the product, too — set up tighter and resist loosening under vibration.

The identifying X on the cross-recessed-head identifies the X-tra quality of Phillips Screws at a glance. Be sure to specify "Phillips."



PERFECTLY MATED!

Only Phillips Drivers are perfectly mated to Phillips Screws. Look for the name Phillips on the shank.

PHILLIPS *Cross-Recessed-Head* **SCREWS**

✖ *marks the spot... the mark of extra quality*

AMERICAN SCREW COMPANY • ATLANTIC SCREW WORKS, INC. • THE BLAKE & JOHNSON CO.
CENTRAL SCREW COMPANY • CONTINENTAL SCREW COMPANY • THE EAGLE LOCK COMPANY
ELCO TOOL AND SCREW CORPORATION • GREAT LAKES SCREW CORPORATION • THE H. M. HARPER CO.
THE LAMSON & SESSIONS COMPANY • NATIONAL LOCK COMPANY
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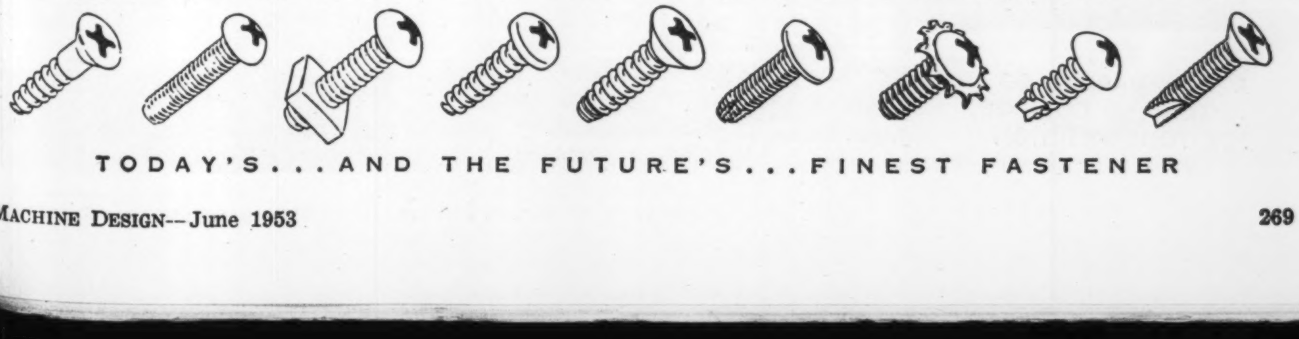
PHEOLL MANUFACTURING CO. • ROCKFORD SCREW PRODUCTS CO. • SCOVILL MANUFACTURING CO.
SHAKEPROOF DIV. OF ILLINOIS TOOL WORKS • THE SOUTHINGTON HDWE. MFG. COMPANY
STERLING BOLT COMPANY • WALES-BEECH CORP.



TODAY'S...AND THE FUTURE'S...FINEST FASTENER

AUTOMATION
means
Greater Profit
AUTOMATION
Your machines plus Eagle Timers

7200°
7200° DIAL

SPEED-UP PRODUCTION WITH MICROMETER ACCURACY

The patented Microflex Threaded Axle and Pinion uses 20 turns of the dial. Multiplied 20 times, 7200°, for more accuracy.

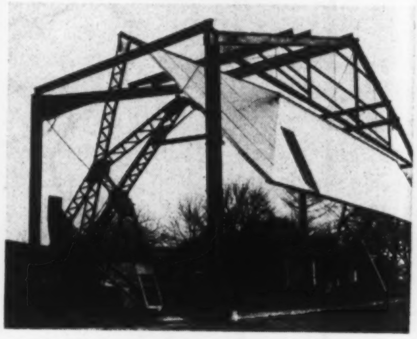
You can increase the accuracy of your machines, reduce human errors and speed up production, for greater profit. There is a staff of "know-how" engineers at Eagle, ready to suggest the right answer to your production problems without obligation. Let Eagle Automatic timing increase production and profit for you.

A WIDE VARIETY OF TIMERS AND COUNTERS FOR YOUR SELECTION

EAGLE SIGNAL
Industrial Timers
EAGLE SIGNAL CORPORATION MOLINE, ILL.

make possible conversion from one process to the other with a minimum of down time and auxiliary handling equipment.

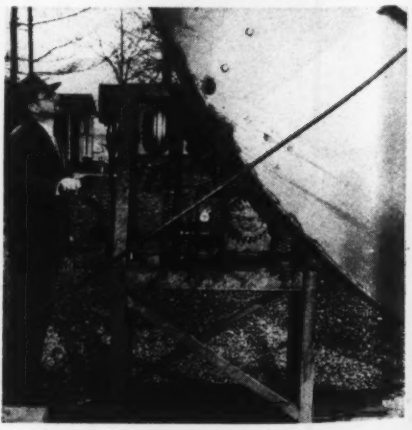
Hangar Doors Open in 30 Seconds



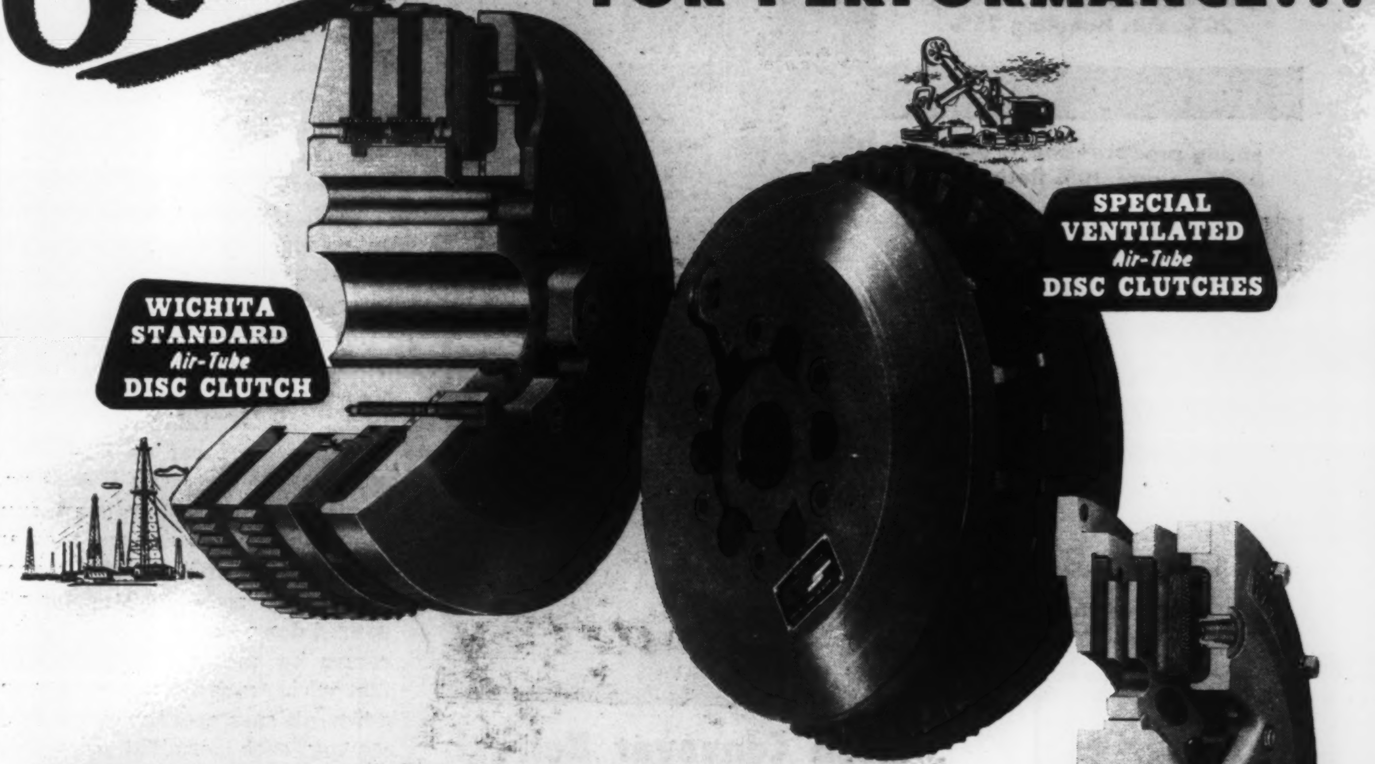
Developed for use on Air Force alert hangars, a counterbalanced door which opens in 30 seconds will make it possible for a jet interceptor aircraft to start its motors, taxi out and be airborne in one to two minutes. Construction of hangars using these doors, developed by the Luria Engineering Co., was expected to be completed in May.

The door is a single leaf 64 feet wide and 23 feet high; weight is 5 tons. Trunnions at each end of the door are mounted on structural steel pedestals anchored to foundations which are independent of the hangar structure. Though normally opened and closed by electric power, the doors can be manually opened in 90 seconds in case of power failure.

Emergency mechanism allows manual opening of five-ton hangar doors in 90 seconds



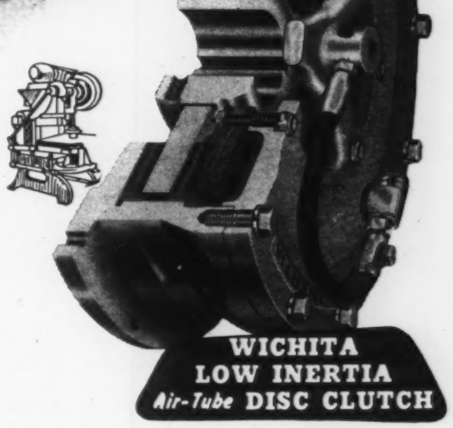
Sensational FOR PERFORMANCE...


WICHITA STANDARD *Air-Tube* DISC CLUTCH
SPECIAL VENTILATED *Air-Tube* DISC CLUTCHES

WICHITA *Air-Tube* CLUTCHES

These three simple, compact, powerful, trouble-free Air-Tube friction clutches combine all the advantages inherent in air operation, such as: convenient remote control, small manual pressure required for full torque, smooth starting and quick disengagement.

They are engineered to give longer service at a lower operating cost because each requires very little maintenance. Many test runs of Wichita Clutches have exceeded 2½ million engagements and still no failures occurred. Such performance is proof of the sound engineering behind Wichita Clutches. Pick the Clutch *you* need for the job! *Call the nearest Wichita Engineer for complete detailed information.*


WICHITA LOW INERTIA *Air-Tube* DISC CLUTCH

OTHER OUTSTANDING ADVANTAGES

- **Safer Operation**
- **Cooler Running**
- **Minimum Slippage**
- **No Backlash**
- **Built in Standard and Low Inertia Types, All Positively Ventilated**
- **No Lubrication**
- **No Adjustments**

WICHITA *Falls*

WICHITA FALLS, TEXAS, U. S. A.

CALL THE WICHITA ENGINEER NEAREST YOU

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Ad 6DN

RESULT STORIES THAT RING THE BELL!

glass decorator ups capacity 20%, cuts handling 25%

spring producer boosts output 350%, saves 30% floor space

cotton processor licks costly fire problem

fish packer cuts handling time

coal producer speeds drying cycle

Cambridge Wire Mesh Conveyor Belts have helped produce these cost-saving results in plant after plant across the nation.

Wouldn't it be a good idea for you to investigate how these amazingly versatile conveyor belts can combine movement with processing in the equipment you are building?

They can be used at temperatures ranging from sub-freezing for food packers, to as high as 2100° F. for heat treating. They can be used in corrosive solutions such as pickling acids or in ordinary water if your product must be washed during processing. Open mesh of the belt allows free circulation of process atmospheres, free drainage of process solutions. All-metal construction means long life and low maintenance. They're available in any metal or alloy, mesh or weave, length or width.

Best of all, Cambridge has a solidly experienced Field Engineering staff at your service. Look under "Belting-Mechanical" in your classified telephone book for the man nearest you. Call him in at any time.

Incidentally, we'll be glad to send you details on any of the result stories described in the heading of this advertisement.

FREE, FOR YOUR OWN STUDY —NEW, 140 page Cambridge Belt Catalog illustrates and describes wire mesh belt specifications, gives conveyor design sketches and metallurgical data. It's must-reading for economy minded designers! Write for yours!

The Cambridge Wire Cloth Co.

WIRE CLOTH | METAL CONVEYOR BELTS | SPECIAL METAL FABRICATIONS

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Cambridge 6,
Maryland

OFFICES IN PRINCIPAL INDUSTRIAL CITIES

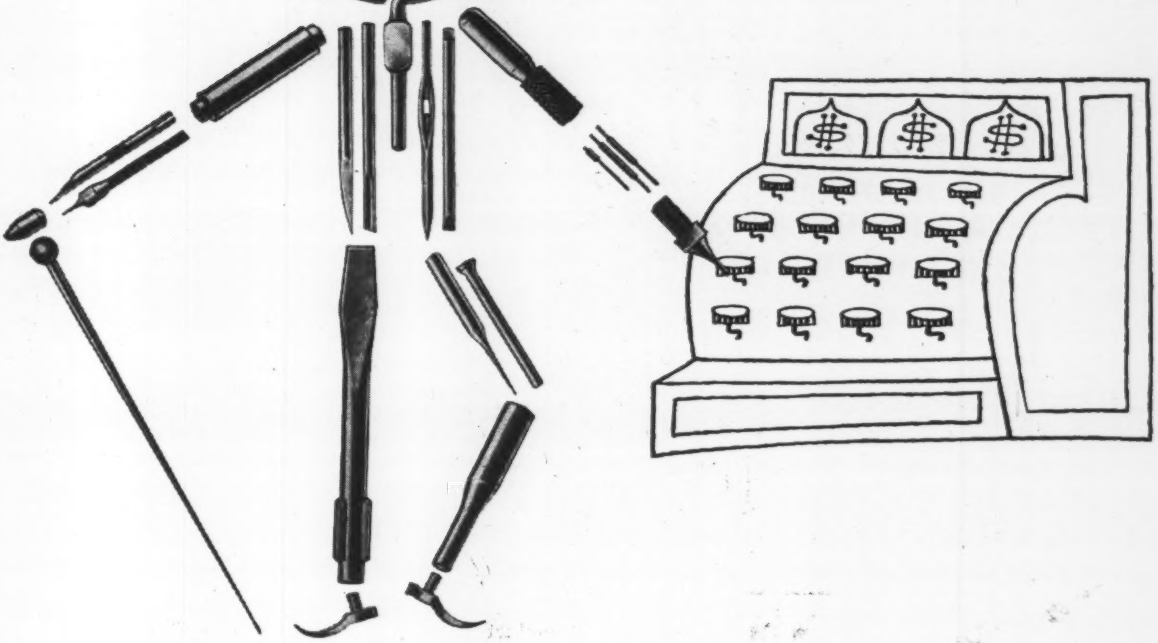
Traffic Flow Controls Operatorless Elevators

Completely automatic, the Automatic Traffic Pattern control elevator system developed by Westinghouse Electric Corp. selects the most efficient pattern for every condition of traffic encountered during a 24-hour day.

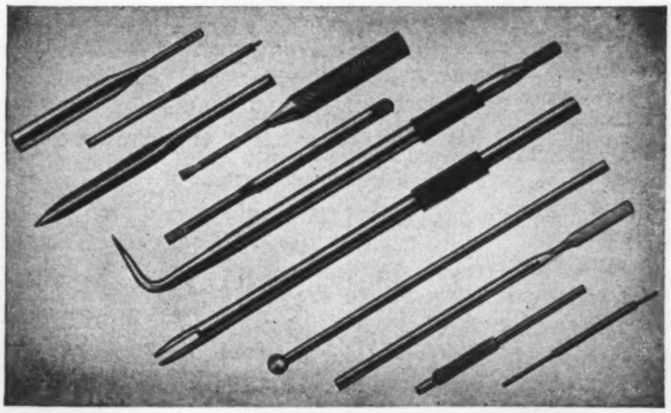
If traffic flow is predominately up, the traffic pattern places all cars on Up-Peak, providing maximum service up from the main floor by starting the cars after a proper interval or as soon as they become loaded and returning each car to the main floor as soon as it has answered its highest passenger or corridor call. Likewise, the system places the car on Down-Peak operation when traffic flow is predominately down. Cars start from the main floor as soon as they are unloaded, reverse at the highest call in each zone and stop for registered down corridor calls as they return to the main floor. When traffic is equally heavy up and down, all cars operate on Off-Peak, leaving each terminal at regular intervals in a manner to keep them evenly spaced. During the period of the day when very few calls exist, the system places all cars on Off-Hours, parking them at the main terminal ready to answer any calls. Motor-generator sets auto-

Telephone type relays are part of intricate controls for the first completely automatic office building operatorless elevator system

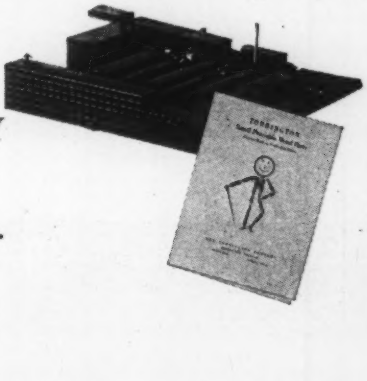
There's profit in it for you!



Let Torrington make your small precision metal parts



If your product uses special pins, pivots, dowels, needles, mandrels, knives or other small precision metal parts, TORRINGTON can make them better, faster, less expensively than you can. Specially-designed automatic machinery draws, grinds, swages, knurls, slots, bevels and rolls threads on production runs to high precision standards.



Write for your free copy of Condensed Catalog which shows an even greater variety of precision parts that can be produced quickly and economically. Or send your blueprint for a prompt quotation.

THE TORRINGTON COMPANY
Specialties Division
110 Field Street Torrington, Conn.
Makers of
TORRINGTON NEEDLE BEARINGS

Leather Oil Seals
TRUST
TROSTEL
Leather Packings
Synthetic Rubber Packings
Synthetic Rubber Oil Seals
TROSTEL QUALITY

Rigid laboratory control PLUS 100% inspection assures *Consistent Quality*

When the reputation of a product depends on the unfailing performance of a seal . . . you need *quality you can trust.*

Here, at Trostel, quality control procedures are an integral part of the packings specification itself . . . and these carefully worked out procedures are rigidly enforced during processing and manufacture by one or more of *three* separate laboratories. Then, to make doubly sure, each individual packing and oil seal must pass a comprehensive visual inspection before it can be released for shipment.

We invite you to join the growing list of major equipment manufacturers who know from their own experience: "*You can trust a Trostel seal.*"

Illustrated Bulletin On Request

ALBERT TROSTEL PACKINGS, LTD., Lake Geneva, Wis.

Formerly Division of Albert Trostel & Sons Co., Milwaukee, Wis.

BRANCH OFFICES
NEW YORK
LOS ANGELES
SAN FRANCISCO
SEATTLE · HOUSTON
WORCESTER, MASS.

TROSTEL packings

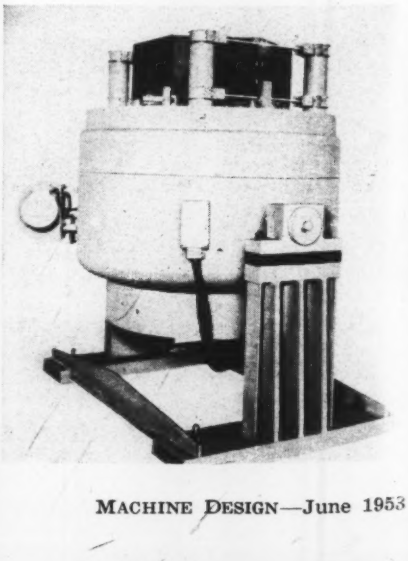
matically shut off when no calls are made and start as each car responds to registered calls.

One car at a time is loaded at the main floor. If two cars arrive simultaneously, the doors of the second car remain open long enough to allow passengers to leave and then close until the other car is dispatched. Full cars stop only at floors selected by passengers in the car, leaving corridor calls for less crowded cars.

Vibration Exciter Delivers 10,000-Pound Force

A recently announced electromagnetic vibrator is claimed to be capable of continuous duty at 10,000 pounds force output. The table is supported on specially designed forged steel flexures which are said to insure straight-line motion and elimination of resonance within the 5 to 500 cps operating range of the equipment. Stiffness of the flexure permits placing heavy loads on the table without sacrificing a large portion of the available one-half inch stroke. Operation in any position is possible.

Power supply for the unit, made by the MB Mfg. Co., consists of three alternators, 50 hp ac motor, dc generator, dc field exciter and a dc motor. Controls for frequency and force are supplied in addition to selector switches for the three alternators which drive the vibrator's driver coil. Completely interlocked, the controls prevent incorrect starting or operation.



Case History M-119

Here's what we mean by SUPERIOR ENGINEERED FOUNDRY PRODUCTS...

PROBLEM:

1. This 55-pound cast steel rear spring lock out beam was failing in service.
2. Because the design was not compatible with good foundry practice, it was impossible to consistently produce quality castings.
   - **(a)** An excessive number of feeding risers was required to eliminate a shrinkage condition at the heavy rib junctions.
   - **(b)** The long, deep, narrow pockets were the cause of sand being washed off and becoming trapped in the metal as the casting was being poured.

SOLUTION:

Stress analysis of the original design, in Superior's own stress analysis laboratory, revealed the stresses to be too high and the ribs to be stress risers. Therefore, the design must be modified in order to carry the service loads.

RESULT:

1. Superior's Engineered Foundry Design reduced the critical stress 57.5%, eliminating service failures. Strength was increased 235%, weight reduced 3.2 pounds.
2. The redesign is compatible with good foundry practice and enables the foundry to consistently produce castings that meet the high standards required.
   - **(a)** Elimination of the heavy rib junctions reduces the number of feeding risers required to produce sound castings.
   - **(b)** Trapping of sand in the metal during pouring is prevented because the deep pockets have been reduced.

IT PAYS TO PAY ATTENTION TO CASTING DESIGN

YOU, TOO, CAN BENEFIT BY CONSULTING SUPERIOR'S PRODUCT DEVELOPMENT SERVICE.

If it can be cast, Superior's service developes the best design in which to cast it. If it shouldn't be cast, Superior's service developes the reasons why.

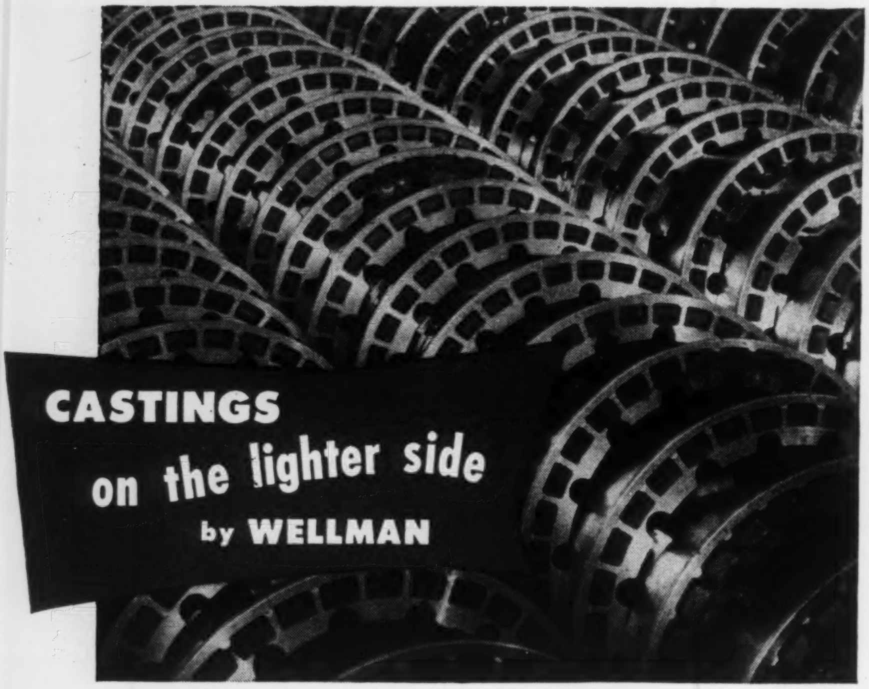
SALES OFFICES: CHICAGO 4, 332 S. Michigan Ave., DETROIT 35, 18050 James Couzens Highway, ST. LOUIS, 9008 Harrison Ave., Brentwood 11, BUFFALO, 2107 Kensington Ave.

ENGINEERED FOUNDRY PRODUCTS

Since 1916

SUPERIOR STEEL AND MALLEABLE CASTINGS CO.

BENTON HARBOR, MICHIGAN, U. S. A.



If you're thinking along the lighter side about the whole subject of magnesium and aluminum castings, think about Wellman as a source.

As the contractor, standing in one room of his new inexpensive house, said to a friend in the next room, "You can *hear* me, but you can't *see* me? Them's some walls, ain't they!" . . .

"Them's some walls" on a Wellman lightweight magnesium casting, too, thin in appearance but tough enough for our biggest jet bomber landing wheels . . . and easy to machine!

Let us show you how our four complete plants and almost a half century of experience can help you. Write for our new catalog No. 53.

Well-Cast MAGNESIUM AND ALUMINUM CASTINGS
Well-Made WOOD AND METAL PATTERNS

THE WELLMAN BRONZE & ALUMINUM CO.
Dept. 10, 12800 Shaker Boulevard Cleveland 20, Ohio

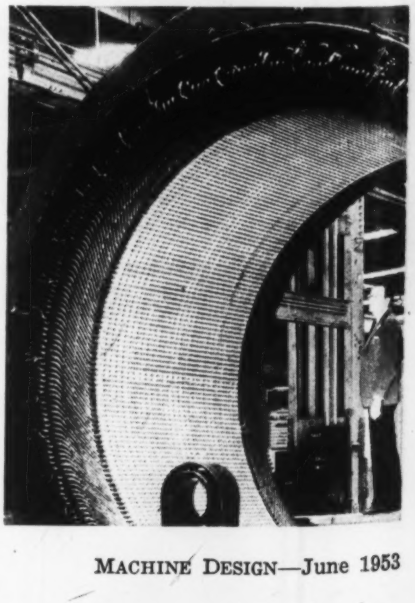
Plenty of Time To Plan Moon Excursion

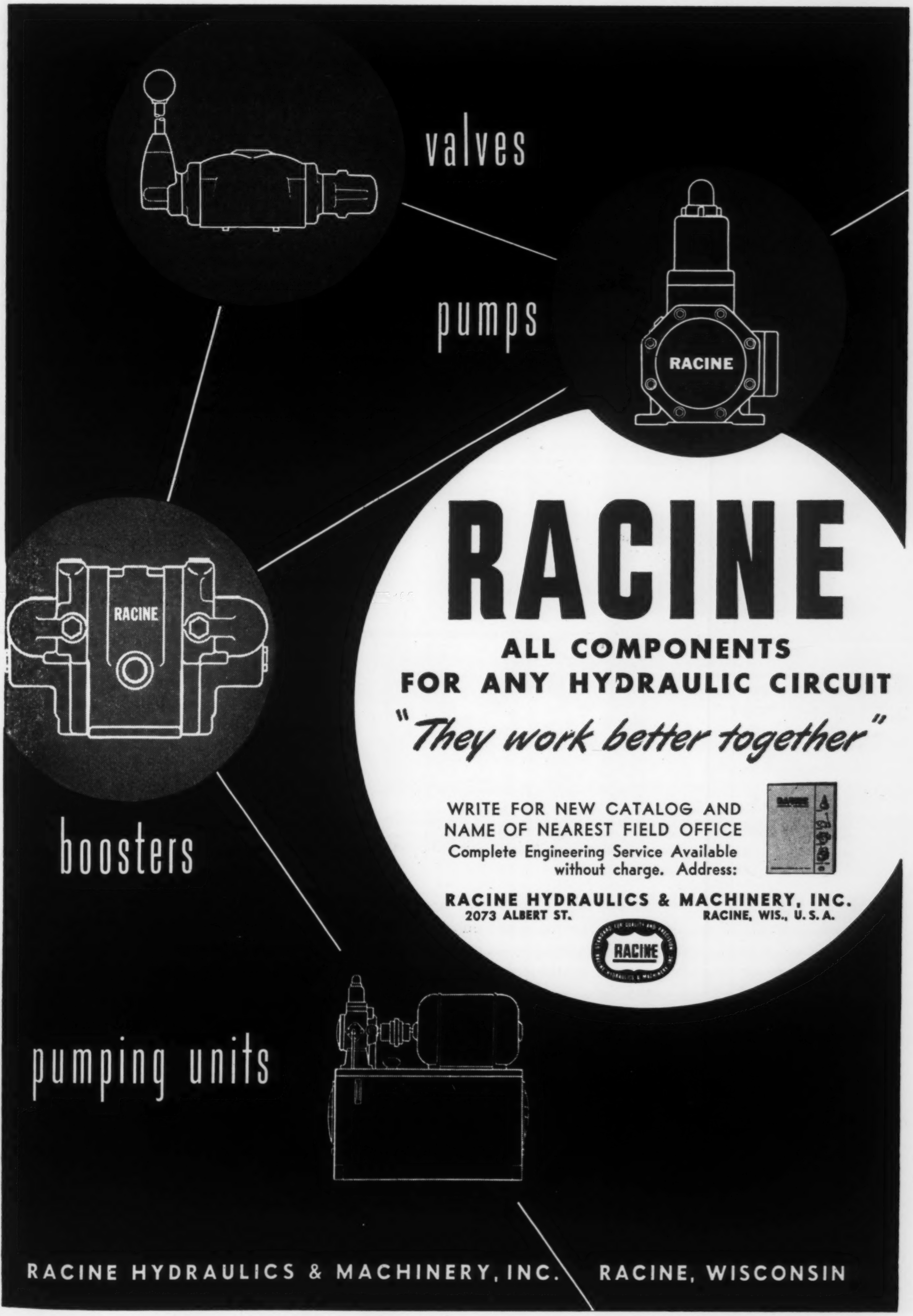
"Such sensational things as pushbutton warfare, man-made satellites, and rockets to the moon are not yet with us. We are still a long, long way from such things as space stations and lunar rockets," General T. K. Vincent, Director of the Army's Research Program on Guided Missiles and Rockets, recently declared.

One of the more important reasons for this situation is high cost. Even a small guided missile is a decidely expensive item, the General stated, and pointed out that the guided missile is the most complex mechanism that has ever been launched into the air. A guided missile is made up of several hundred components, he explained, and these as well as the missile itself, must be light in weight, able to withstand extremely high and low temperatures and withstand large forces.

◆

SUPER STATOR: To be used with three others in creating supersonic air blasts for aircraft and guided missile research, this 50-ton stator dwarfs a 45-pound stator for a 5-horsepower motor. The giant General Electric wind tunnel motors will generate a maximum of 216,000 horsepower, the greatest load ever concentrated on a single shaft. Destined for use at the National Advisory Committee for Aeronautics' Ames Aeronautical Laboratory at Moffett Field, Calif., the complete unit will weigh 685 tons

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pumps
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RACINE
boosters
pumping units
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**ALL COMPONENTS
FOR ANY HYDRAULIC CIRCUIT**

"They work better together"

WRITE FOR NEW CATALOG AND
NAME OF NEAREST FIELD OFFICE
Complete Engineering Service Available
without charge. Address:

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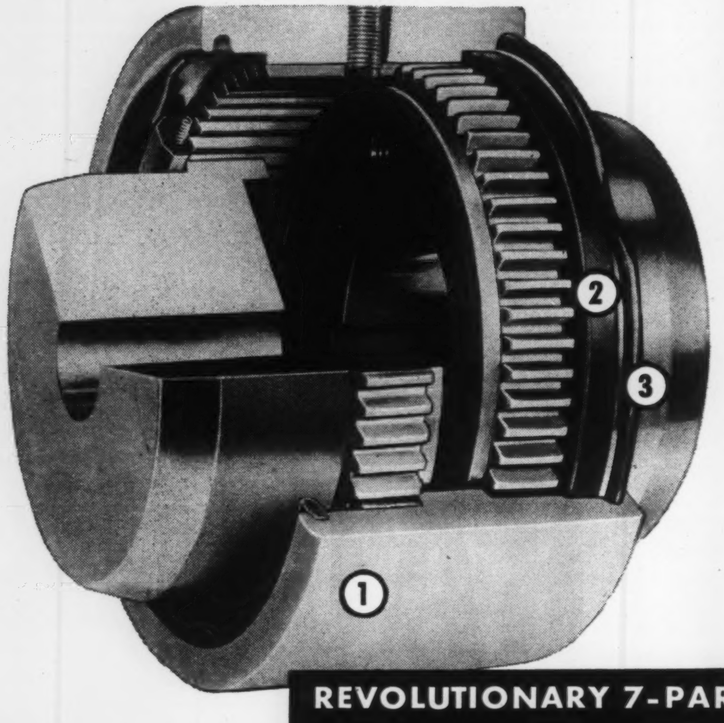
2073 ALBERT ST. RACINE, WIS., U. S. A.

RACINE HYDRAULICS & MACHINERY, INC. RACINE, WISCONSIN

SIMPLEST

Gear Coupling Made



REVOLUTIONARY 7-PART

Sier-Bath

Flexible

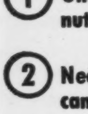
GEAR COUPLINGS

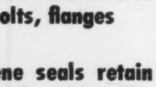
1. **One-piece smooth sleeve—no nuts, bolts, flanges**
2. **Neoprene seals retain lubricant—seal out corrosion**
3. **Assembled with snap rings in seconds by hand**

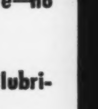
SLASH COSTS wherever you are now using flange-and-bolt type flexible gear couplings. Sier-Bath Couplings are only 3/5 their size, ½ their weight—allow more compact designs . . . cut power costs . . . reduce wear on shafts, bearings, armatures. Assembled and uncoupled in *seconds* instead of minutes, they slash assembly costs and down-time. Corrosion can't bother them because no major metal parts are in exterior contact. Available in standard types (shown below) in sizes ⅞ to 6, HP 4 to 600 per 100 RPM. Special types and sizes on request. See your local Sier-Bath Distributor or Representative, or send for our NEW *16-page* CATALOG. *Coupling Division, Sier-Bath Gear & Pump Co., Inc., 9245 Hudson Blvd., North Bergen, N. J.*

Founded 1905

Member A. G. M. A.


Standard


Mill Motor


Vertical Shaft

Floating Shaft

Spacer

Also Manufacturers of Precision Gears . . . Screw, "Gearex" and "Hydrex" Rotary Pumps

Seek to Place Engineers Discharged from Services

As a positive step in the satisfactory placement of engineers, the Engineering Manpower Commission of Engineers Joint Council is sending letters to deans of engineering requesting continuance of campus placement bureaus. At the same time EMC is reminding engineering graduates now in service of the existence and value of such placement facilities. Interest shown in the latter appeal indicates that campus placement agencies will be approached by an increasing number of engineers as they complete their military service.

Response to this campaign from directors of placement offices provides several examples of projects aimed at placing engineers. The Office of Personnel and Placement at Rutgers University has sent letters offering its services to students who graduated in 1949, 1950, 1951 and 1952. The letter states that the placement office staffs are ready and anxious to serve graduates and asks them to fill in a resume which will be kept on file.

At Virginia Military Institute 95 per cent of the graduates do not continue in military careers and thus desire placement after their first tour of active duty. Many graduates are hired by industry for the few months between graduation and military call and are often able to complete the primary phase of company training programs. Letters containing career information and the continuing offer to be of assistance in placement are sent periodically to the graduates. Response to these letters has been received from 98 per cent of the classes of 1948-1951. It is interesting to note that VMI has no official placement bureau; the project is carried on by R. A. Marr Jr., professor of civil engineering.

Pooling of facilities has resulted in a much more efficient and productive program, according to the Rocky Mountain College Placement Officers Association, which has passed a resolution offering its services to anyone being released from the Armed Forces, regardless of his college affiliation.

New Career Booklet Available for Engineers

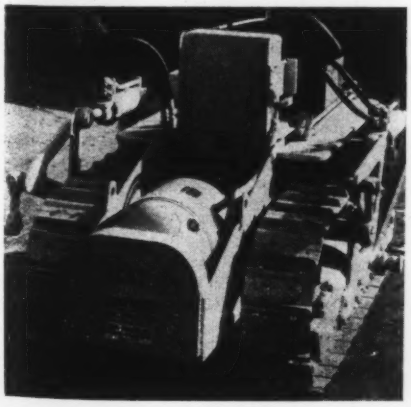
Entitled "Engineering—A Creative Profession," a new color-illustrated booklet is available from the headquarters office of the Engineers Council for Professional Development, 29 West 39th St., New York 18, N. Y. Presenting the "who, what, where and why" of engineering, the new booklet replaces "Engineering As a Career," now out of print, as the basic guidance pamphlet for people considering the engineering profession as a career. Price is $.25 per copy, and purchasers of 50 copies or more receive a 20 per cent discount.

Aluminum Finish Shows High Corrosion Resistance

A new finishing and coloring process for aluminum, called D'Orium, is said to impart remarkable corrosion resistance and a permanent brilliant finish. Six shades of gold as well as other colors are possible using this method, which is an electrochemical process similar to anodizing. Developed in

◆

ELECTRIC 'DOZER: This special caterpillar bulldozer is powered electrically to eliminate exhaust gases so that it can be used safely underground. Shephard Tractor and Equipment Co. built the unit, installing a General Electric Tri-Clad 40-hp, 900-rpm motor which drives the regular transmission with four speeds forward and one reverse. The motor operates on 220/440-volt current transmitted by a trailing cable from a source outside the tunnel



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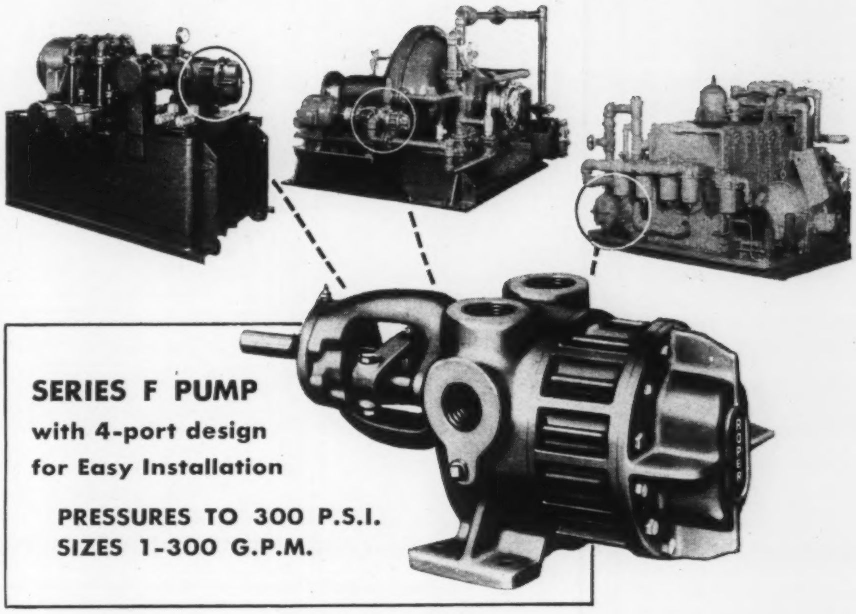
POSITIVE CONTROL *for Hydraulic Circuits*



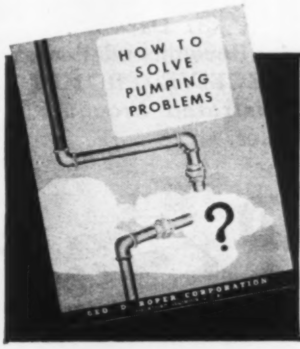
SERIES F PUMP
with 4-port design
for Easy Installation

PRESSURES TO 300 P.S.I.
SIZES 1-300 G.P.M.

Whether you are planning one special machine or hundreds on a production run, consider putting a Roper on the job. Consider 4-port design of the Series F (eight optional piping arrangements — 4 for CW and 4 for CCW rotation) for ease of installation and servicing. Consider, too, the Roper principle of only two moving parts . . . equal size gears operating in axial hydraulic balance . . . standard or stainless steel fitted models, as desired . . . heavy duty flange type bearings. Pumps are supplied with or without relief valve . . . with packed box or mechanical seal. Yes . . . consider Roper for *your* hydraulic applications.

Send for Your Free Copy of New Roper Fact-Packed Booklet!

A valuable 36 page guide that includes tables, charts, and other data relative to the average pumping job. Send for your free copy . . . use coupon below.



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Rockford, Illinois

Please send copy of your latest catalog and new booklet "How To Solve Pumping Problems".

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For FINE GEARS

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If you use DIFFERENTIALS in the product you build, we believe it will pay you as it has others to check with Fairfield on all of your requirements. Fairfield offers (1) Mass Production Economy, (2) Unexcelled Quality, (3) Dependable Service, (4) Expert Engineering Recommendations. YOUR INQUIRY WILL RECEIVE PROMPT ATTENTION. *Send for illustrated brochure, describing Fairfield's facilities.*

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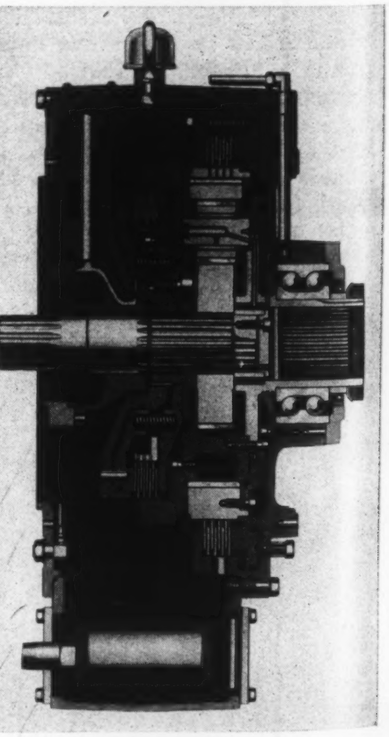
Tests made by the U. S. licensee on a gold colored sample show exceptional resistance to perspiration, acids, salt spray, wear and weathering. Due to the insulating properties of the coating, galvanic corrosion seems to be impossible. Microscopic measurements of a sectioned sample show the coating to be only 0.0002-inches in thickness.

Oil-Actuated Clutches Ease Shifting of Transmission

Multiple disk clutches, engaged by oil pressure, allow "finger-tip" shifting of a new dual range transmission. Designed to obtain extended full range performance from torque convertors, the unit has direct drive and a single stage planetary gear system. Reduction gear ratio may be 2.69 to one or 3.07 to one. Manufactured by the Twin Disc Clutch Co., the transmission is designated Model T-302.

Shifting is controlled by a spool-type valve on the transmission which directs oil to one of the clutch actuating pistons for high or low range operation, or prevents



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for every industry

When you need electric motors . . . in any rating, or frame type . . . one or a thousand . . . *always* look for the Fairbanks-Morse Seal. For over 120 years it has stood for the finest in manufacturing integrity to *all* industry.

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Fairbanks-Morse QZK Motors—in a complete horsepower range.

FAIRBANKS-MORSE

a name worth remembering when you want the best

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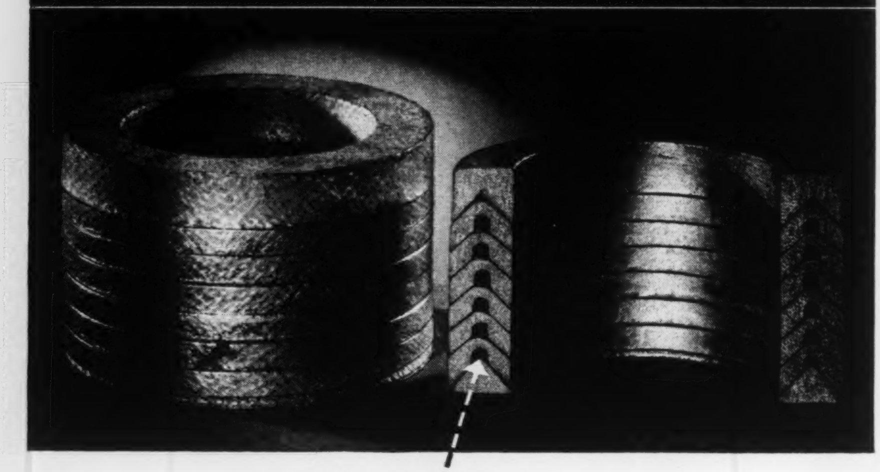
CHEVRON* PACKING



Exclusive hinge-like construction assures a positive, low-friction seal

At every pressure—from the lowest to the highest—Garlock CHEVRON packing provides a positive, low-friction seal. CHEVRON is ideally suited for use on hydraulic cylinders (both single-acting and double-acting), hydraulic rams, plungers of pumps and other reciprocating rods.

The exclusive hinge at the apex of each ring makes this packing flexible and sensitive to pressure changes. When the pressure is on, CHEVRON packing seals firmly both on the inside and outside edges. When the pressure is off, CHEVRON packing maintains a positive seal yet allows the ram or rod to return without binding. This automatic action not only prolongs the life of the packing but also increases the efficiency of the equipment on which it operates.

That is why many manufacturers of hydraulic cylinders, jacks, lifts and presses use Garlock CHEVRON packing exclusively.

Whether your job is plant maintenance or manufacturing new equipment, ask us about CHEVRON packing—the exclusive product of Garlock's own factories. Garlock CHEVRON packing is available in many materials such as: cotton duck with rubber or neoprene binder, asbestos with rubber or neoprene binder, hycar, "Teflon," and "Kel-F."

THE GARLOCK PACKING COMPANY, PALMYRA, NEW YORK
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GARLOCK

PACKINGS, GASKETS, OIL SEALS,
MECHANICAL SEALS, RUBBER EXPANSION JOINTS

flow to either clutch when the transmission is in neutral. For low range operation, the clutch locks the planetary external or ring gear to the transmission housing and the planetary carrier, driven by the sun gear, drives the output shaft. In high or direct drive the input shaft drives the planetary carrier through another oil operated clutch.

Magnesium Production Cut Back by Government

As the result of a review by the Munitions Board of current and future requirements, five of the government's six magnesium plants will cease production. This cutback will reduce overall government output from approximately 196 million pounds a year to approximately 80 million pounds, the rated capacity of the one government-owned plant which will remain in production. Private plants produce approximately 56 million pounds a year.

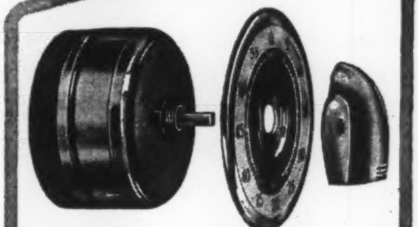
The government's largest plant, which produces magnesium from sea water, will be kept in operation. This plant, operated by the Dow Chemical Co., is at Velasco, Tex. Two of the remaining plants will be leased to the present operators for production of other materials, and all five plants will be held in readiness to resume magnesium production on short notice if necessary.

Challenges American Industry To Interpret Research Results

Unless government research findings are translated into standards and specifications necessary for better production, the nation is in danger of losing the research data developed by the Federal government, according to W. J. Harris Jr., executive secretary of the Minerals and Metals Advisory Board of the National Academy of Sciences. Speaking at a meeting of the Standards Council of the American Standards Association, Dr. Harris said that one-fourth of the nation's research outlay this year is being carried on by the Federal government.

Organizations which heretofore

You can depend on the rugged MARK-TIME "5400" Bell Time Switch



SPECIFICATIONS

UL approved for 20 ampere, 125 volt, 1 HP or 10 ampere, 250 volt operation, AC only. Timings available from 60 seconds to 5 hours. Normally supplied with center stud mounting. Other mountings available on request.

This Mark-Time switch is built to uphold the reputation of your product. Install it in your appliances, devices or machines, and give your customers a *double-purpose* time switch. "5400" turns OFF the circuit at the end of a pre-set time period . . . and gives a clear warning bell signal. Your customers will like that *double* service!

"5400" has a wide range of applications . . . is available with a wide variety of modern dials and knobs . . . can be supplied as an "ON" type of unit on special order.

Write today for full details and prices.

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interpreted and published analyses of such work cannot cope with the volume of reports and data resulting from such large-scale research. "If it is true," states Dr. Harris, "that the end product of research is a standard or a specification, then we would say to you that there is a grave and serious responsibility resting on the standards groups to take advantage of the new knowledge."

Civilian agencies of the government and the Department of Defense require the use of industrial standards and specifications wherever they do not interfere with national defense. In developing new equipment which has no civilian counterpart these agencies must depend on research which is not performed by the usual consumer-producer team, and the possibility arises that they will not be able to utilize commercial standards but will have to develop their own.

Dr. Harris cited titanium, experimental alloys, and ship welding as three areas where standards based on the newest developments are needed.

•

BULLDOZER TRACTOR: Designed to tow a 65,000-pound load at the rate of 25 miles per hour, the "Bull Moose" will level ground quickly and tow heavy artillery pieces. It is over 11 feet high, approximately twice that long and weighs 51,300 pounds with attachments. Besides the 11 by 4-foot dozer blade on the front, the tractor has a cable unit in the rear to operate scrapers. A 300-horsepower diesel engine drives the four-wheel mechanism; front and rear wheels on each side are geared together. Four-wheel hydraulic steering permits simultaneous or independent control of both sets of wheels; thus, the wheels can be turned to move the machine sideways

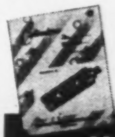
Smoother operating!..

because O-M CYLINDERS air hydraulic have the lowest coefficient of friction of any cylinder

For efficient performance at low pressure, the O-M Cylinder really stands out! Smoothness of bore (4 to 7 micro-inches), and self-adjusting packing reduce friction . . . floating-cushion noses *eliminate binding, dragging, jerking.* This assures a smoother stroke at low or high speeds.

Every O-M Cylinder is ALL cylinder! Interlocking mechanism does away with projecting tie rods and end caps, saving up to ⅓ installation space, and permitting the use of a more powerful cylinder for the job. Easier to install and repack. End plugs tapped for universal mounting, with a complete range of mounting brackets—interchangeable bore for bore. All machined steel, with bearing bronze (no castings)—easily turned down to fit in deep recesses of machines or bases.

14-DAY DELIVERY ON MOST SIZES



Send today for FREE catalog and complete set of ½ and ¼-scale templates showing all cylinders and mounting brackets.

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NEW VITROHM Rheostat

with 6 exclusive features

provides smoother operation, finer control, longer life

1 **Pressed steel base plate** assures a sturdy, lightweight rheostat base. The black japanned finish is corrosion resistant.

2 **Balanced contact arm** reduces creep from vibration or shock. The arm is keyed directly to one end of the drive shaft.

3 **Solid brass rectangular contacts** provide more steps of control for any given plate diameter.

4 **Reflexed collector ring** supplies a self-cleaning surface. It is permanently held in position by Vitrohm enamel.

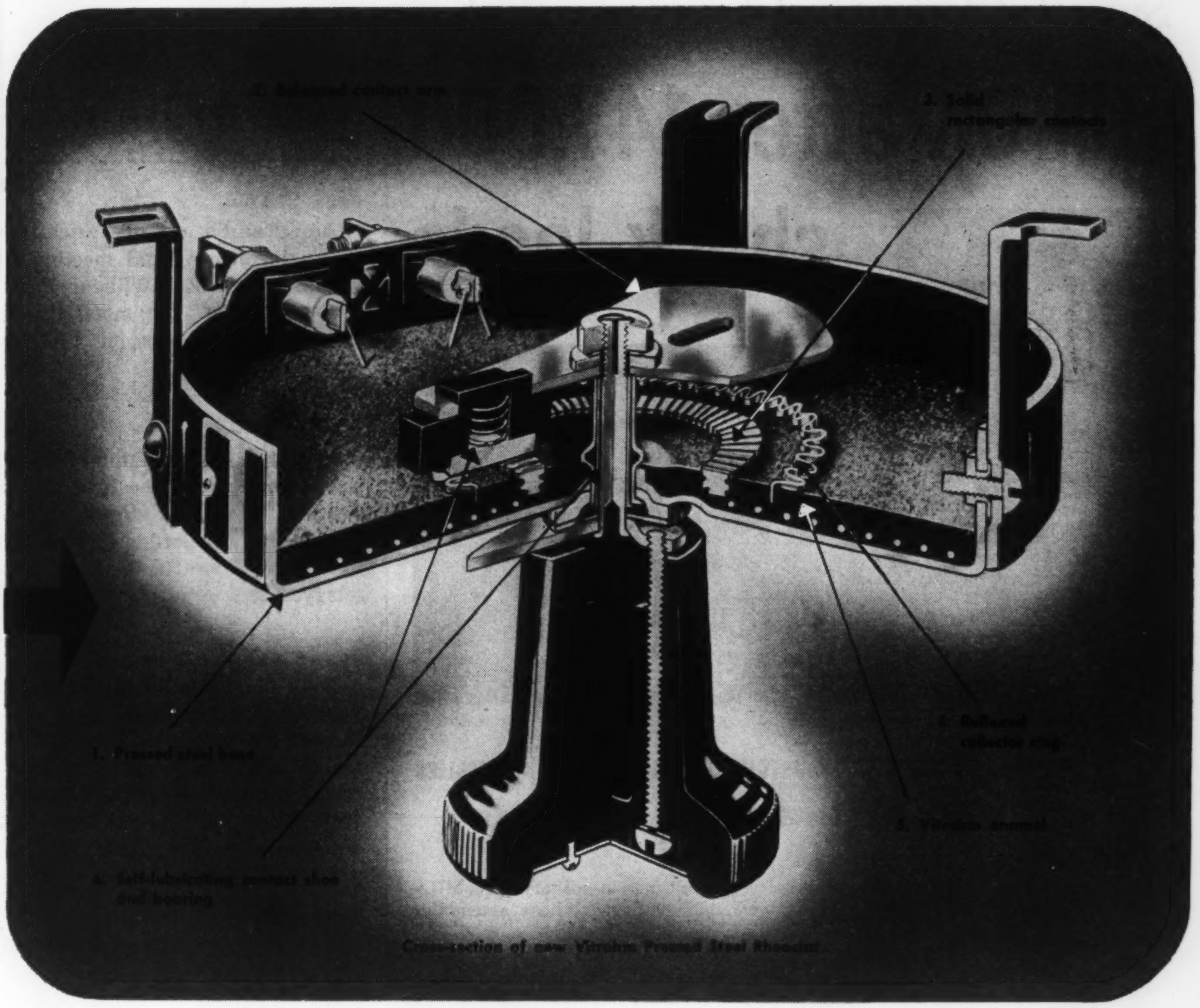
5 **Vitrohm enamel** permanently seals and insulates the resistance element, stationary contacts and collector ring.

6 **Contact shoe and bearing** are self-lubricated to provide exceptionally smooth control and low operating torque.

This new line of Vitrohm Pressed Steel Rheostats incorporates 21 advanced design features, including the 6 shown here. They are designed for a wide variety of industrial applications to give smoother operation, lower operating torque, longer life, and more control steps. From raw materials to finished product, close control over workmanship and continual inspection of every component is maintained. These are the most dependable and economical rheostats ever made by Ward Leonard — the leader in rheostat manufacture for over fifty years.

WARD LEONARD

**WARD LEONARD
ELECTRIC COMPANY**
MOUNT VERNON, NEW YORK
Result-Engineered Controls Since 1892


2. Balanced contact arm
3. Solid rectangular contacts
1. Pressed steel base
6. Reflexed collector ring
5. Vitrohm enamel
4. Self-lubricating contact shoe and bearing

Cross-section of new Vitrohm Pressed Steel Rheostat.

RHEOSTATS FOR EVERY APPLICATION

Ward Leonard manufactures the most complete line of power rheostats ever offered for industrial control applications. It includes standard and special designs for all current ratings up to 400 amperes. A complete description of the entire line with mountings, manual and motor drive accessories, a variety of enclosures, and optional features will be found in the *new* Ward Leonard Bulletin 60a. It will pay you to send today for your free copy. Write to Ward Leonard Electric Co., 58 South Street, Mount Vernon, N. Y.

vitrohm and face plate type

rheostats
bulletin 60a

general information

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WARD LEONARD ELECTRIC CO.

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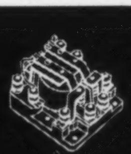
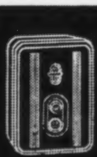
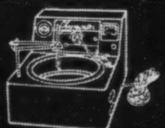
RESISTORS



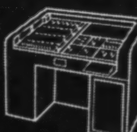
RELAYS



MOTOR CONTROLS



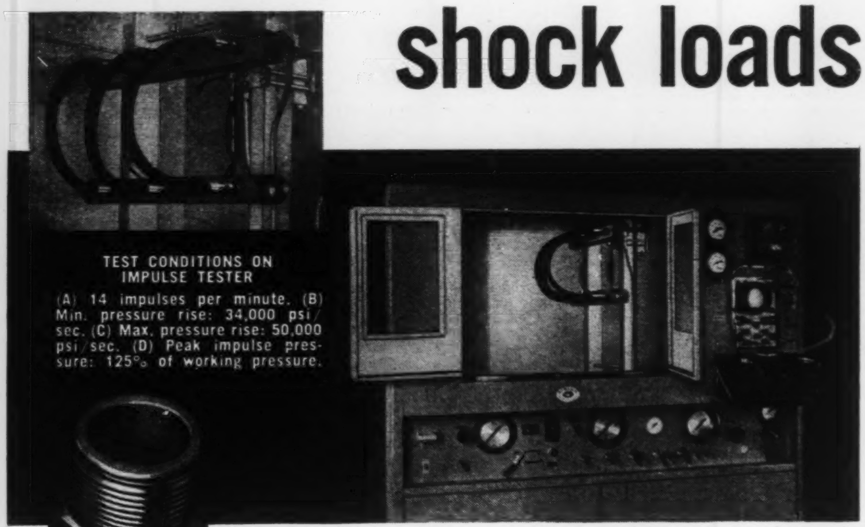
CHROMASTER



DIMMERS

Subjected to toughest hose test . . . yet

still OK after 147,000 shock loads



TEST CONDITIONS ON IMPULSE TESTER

(A) 14 impulses per minute. (B) Min. pressure rise: 34,000 psi/sec. (C) Max. pressure rise: 50,000 psi/sec. (D) Peak impulse pressure: 125% of working pressure.

RESISTOFLEX INDUSTRIAL HYDRAULIC HOSE ASSEMBLIES

offer high burst strength, too!

The hydraulic impulse test, as outlined in military spec. MIL-H-5511, shows how well these *industrial* hose assemblies resist fatigue.

To this 100,000 cycle test, while plenty tough by itself, Resistoflex added a 160°F requirement—making it the toughest hose test yet. Despite this, Resistoflex medium-high pressure assemblies were still going strong after 147,000 cycles . . . at which time attempts to fatigue the assemblies were abandoned as futile.

Built with tough compar tube and high strength synthetic fibre-braid reinforcement, Resistoflex hose assemblies also provide five other features for *more hose value per dollar:*

1. High burst strengths – stay high even as working age increases.
2. High pull strength – more than 3500 lbs. for ½" hose. Couplings won't pull out even under this tension!
3. High impact strength – hose returns to original cross section after crushing load.
4. Full flow fittings – fitting bore equals hose I.D. – Hose constriction at crimp is less than 5%.
5. No gumming or clogging of hydraulic circuit – Compar tube inert to all hydraulic oils.

I.D. (inches)	Working Pressure (psi)	Min. Burst Pressure (psi)	Assembly Tensile Strength (lbs.)
¼	2300	9200	900
⅜	2050	8200	2500
½	1800	7200	3500

Write for Data Sheet MH-1.

RESISTOFLEX
CORPORATION
Belleville 9, New Jersey

SPECIALLY ENGINEERED FLEXIBLE RESISTANT PRODUCTS FOR INDUSTRY

Meetings

AND EXPOSITIONS

June 15-17—

American Society of Agricultural Engineers, Annual meeting to be held at Hotel William Penn, Pittsburgh, Pa. Raymond Olney, P. O. Box 229, St Joseph, Mich., is secretary.

June 15-18—

American Electroplaters' Society. Annual meeting to be held at the Benjamin Franklin Hotel, Philadelphia, Pa. D. Gordon Foulke, 445 Broad St., Newark, N J., is secretary.

June 15-19—

Basic Materials for Industry Exposition. First exposition and conference to be held at Grand Central Palace, New York, N. Y. Additional information may be obtained from Clapp & Poliak Inc., 341 Madison Ave., New York 17, N. Y.

June 15-19—

American Institute of Electrical Engineers. Summer general meeting to be held at Chalfonte-Haddon Hall, Atlantic City, N. J. H. H. Henline, 33 West 39th St., New York 18, N. Y., is secretary.

June 16-19—

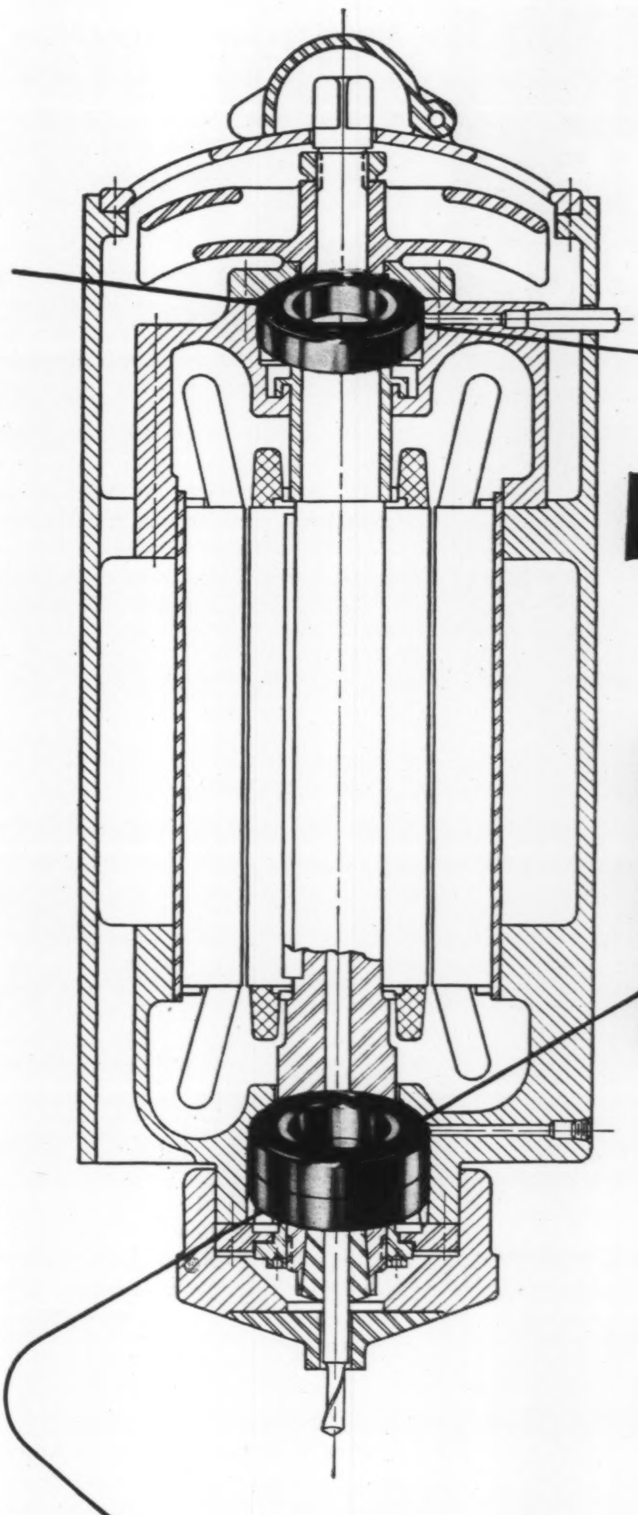
American Welding Society. National spring technical meeting to be held at the Shamrock Hotel, Houston, Texas. Additional information may be obtained from society headquarters, 33 West 39th St., New York 18, N. Y.

June 17-19—

American Management Association. General management conference to be held at Hotel Statler, New York, N. Y. Additional inforation may be obtained from society headquarters, 330 West 42nd St., New York, N. Y.

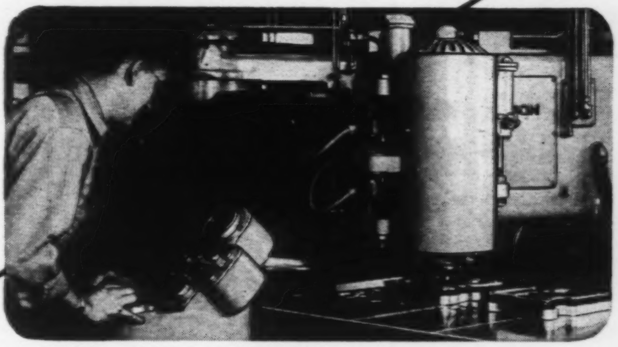
June 18-20—

American Society of Mechanical Engineers. Applied Mechanics Conference to be held at the University



LOOKS SIMPLE

WAIT TILL YOU HEAR WHAT IT DOES!



High-speed, remote controlled router made by Ekstrom, Carlson & Company, Rockford, Illinois.

You guessed it. This is a blueprint of a spindle head. It shows the arrangement of Fafnir Super-Precision Ball Bearings . . . a single bearing at the top, duplexed bearings at the work end. What's unusual about it? Listen to this . . .

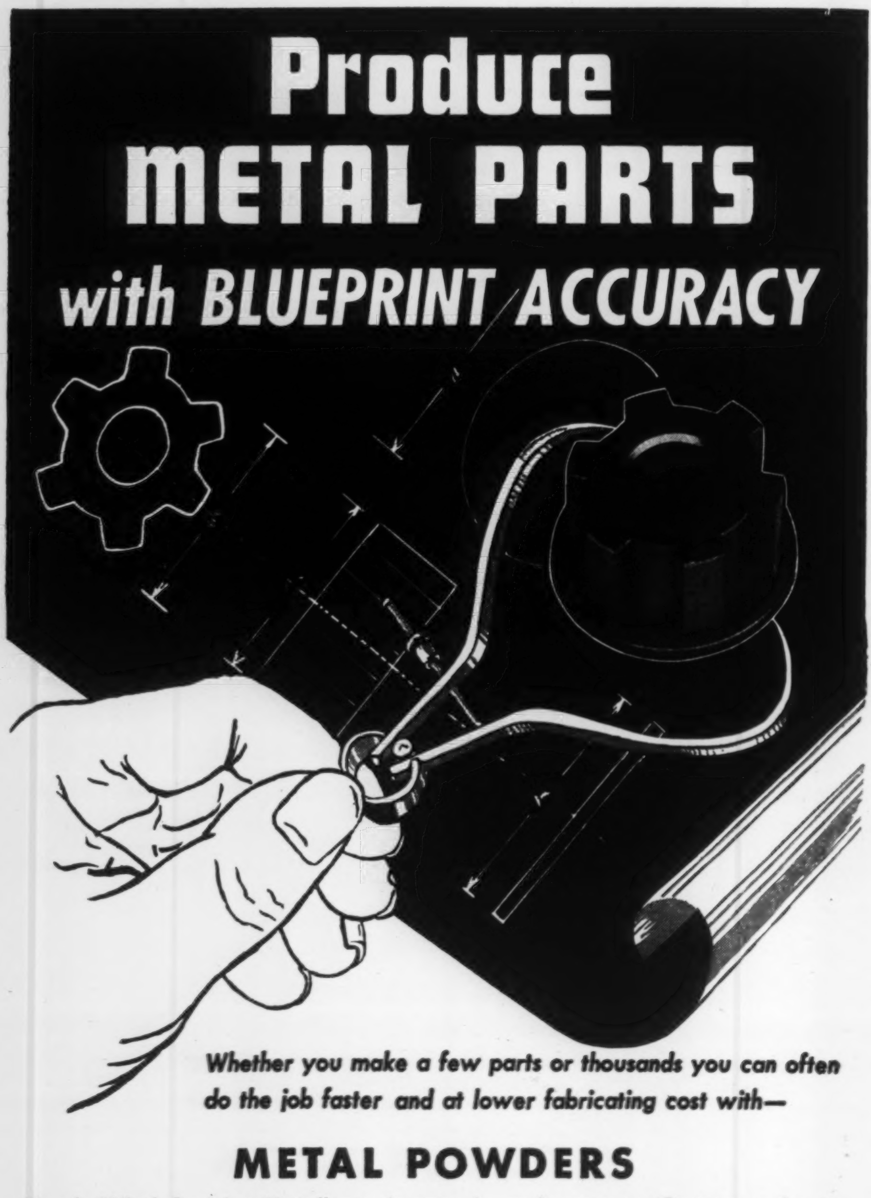
The spindle head is part of an Ekstrom, Carlson high-speed, remote-controlled machine that template routes through 1-inch aluminum plate with a single pass and at cutting speeds as high as 90 inches per minute. It is driven by a 30 h.p. variable speed motor and operates up to 15,000 r.p.m. The radial load on the bearings is as high as 500 to 600 pounds. The spindle head takes tool bits with diameters from 5/16" to 3/4".

Although the top design achievement of this new machine tool is its electrically-controlled hydraulic feed mechanism, the spindle bearing application is no ordinary accomplishment. Fafnir engineers worked hand-in-hand with Ekstrom, Carlson engineers to make it successful. Another example of the Fafnir "attitude and aptitude" . . . a way of looking at bearing problems from the designers' viewpoint, an aptitude for supplying the right bearing to fit the need. The Fafnir Bearing Co., New Britain, Conn.

FAFNIR

BALL BEARINGS

MOST COMPLETE LINE IN AMERICA



Produce
METAL PARTS
with BLUEPRINT ACCURACY

Whether you make a few parts or thousands you can often do the job faster and at lower fabricating cost with—

METAL POWDERS

Here's Why! Powder Metallurgy is speedy and accurate. Parts may be so pressed and sintered that many machinings and other production operations are eliminated or simplified. Parts can be produced to close tolerances.

Powder metal parts are economical. There's no waste metal. Unused powder after pressing can be used again.

SAVE TIME—SAVE COSTS

MD Metal Powders are dependable because they are the result of over 35 years of research and manufacture by MD, the pioneer in metal powder development.

Consult MD for thoroughly experienced advice and names of recognized qualified molders.

METALS DISINTEGRATING COMPANY, INC.
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2126

WORLD'S LARGEST MANUFACTURER OF FINELY DIVIDED METALS

of Minnesota, Minneapolis, Minn. C. E. Davies, 29 West 39th St., New York, N. Y., is secretary.

June 28-30—
Alloy Casting Institute. Annual meeting to be held at the Homestead, Hot Springs, Va. E. A. Schoefer, 32 Third Ave., Mineola, N. Y., is secretary.

June 29-July 2—
American Society of Mechanical Engineers. Semiannual meeting to be held at Hotel Statler, Los Angeles, Calif. C. E. Davies, 29 West 39th St., New York, N. Y. is secretary.

June 29-July 3—
American Society for Testing Materials. Annual meeting to be held at Chalfonte-Haddon Hall, Atlantic City, N. J. Robert L. Painter, 1916 Race St., Philadelphia, Pa., is secretary.

Sept. 6-11—
American Chemical Society. Fall meeting to be held at Hotel Conrad Hilton, Chicago, Ill. R. M. Warren, 1155 16th St., Washington, D. C., is assistant secretary.

Sept. 13-17—
Electrochemical Society Inc. Fall meeting to be held at the Ocean Terrace Hotel, Wrightsville Beach, N. C. Dr. Henry B. Linford, 235 West 102nd St., New York, N. Y. is secretary.

Sept. 21-22—
Steel Founders' Society of America. Fall meeting to be held at the Homestead, Hot Springs, Va. Additional information may be obtained from society headquarters. 920 Midland Bldg., Cleveland, O.

Sept. 28-30—
Association of Iron & Steel Engineers. Annual meeting to be held at Hotel William Penn, Pittsburgh, Pa. T. J. Ess, 1010 Empire Bldg., Pittsburgh, Pa., is managing director.

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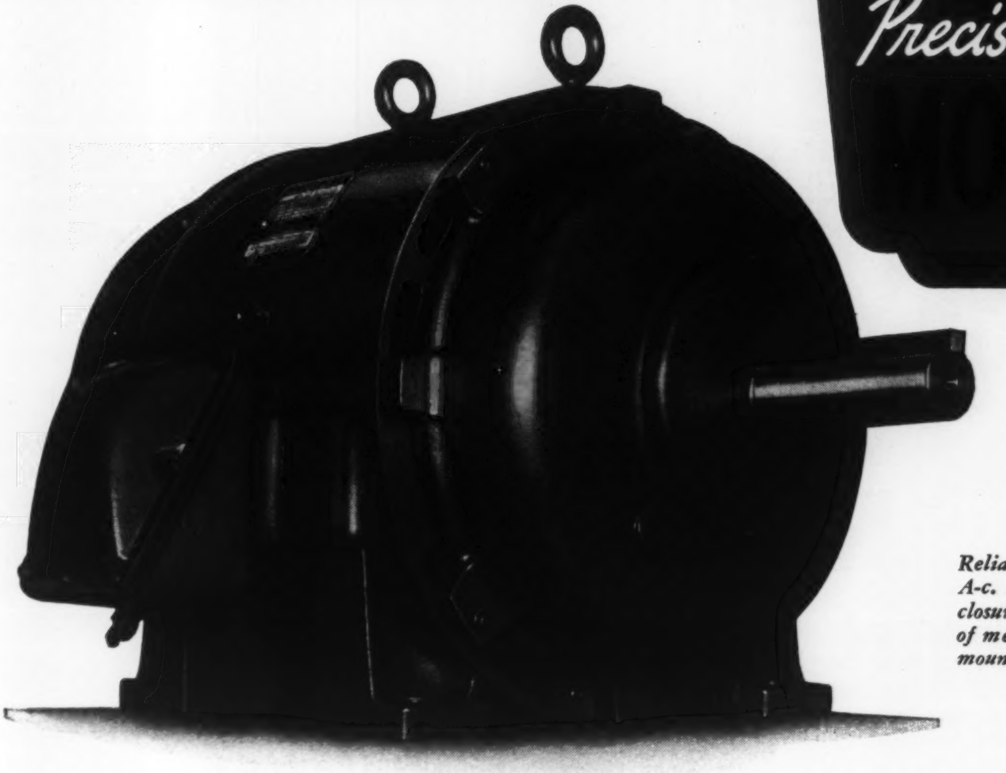

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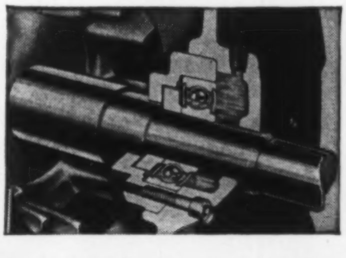

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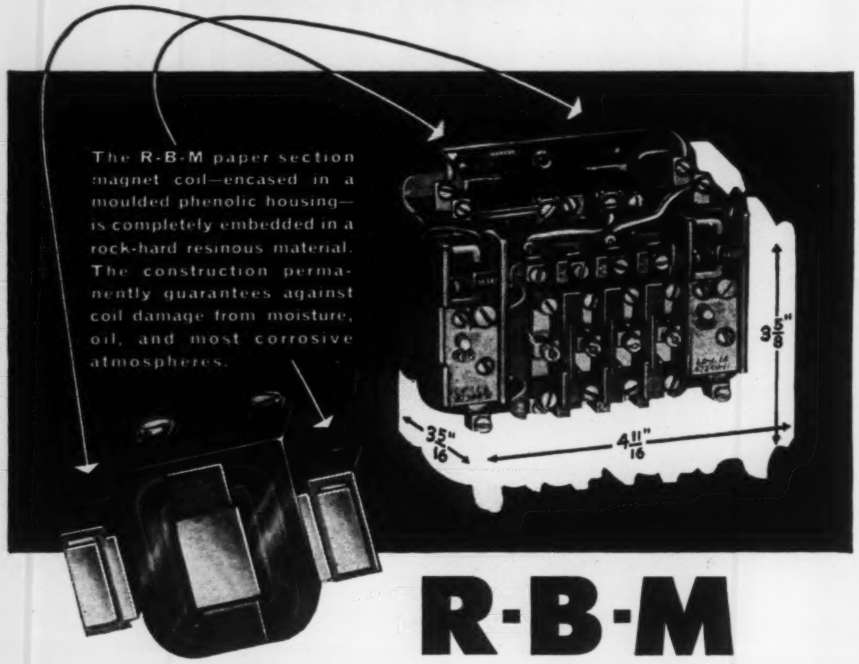

The R-B-M paper section magnet coil—encased in a moulded phenolic housing—is completely embedded in a rock-hard resinous material. The construction permanently guarantees against coil damage from moisture, oil, and most corrosive atmospheres.

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A quick glance immediately shows which overload has tripped.

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Write Dept. F6 for Bulletin 605

RBM

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ESSEX WIRE CORP.
Logansport, Indiana

MANUAL AND MAGNETIC ELECTRIC CONTROLS
—FOR AUTOMOTIVE, INDUSTRIAL, COMMUNICATION AND ELECTRONIC USE

Design Abstracts

(*Continued from Page* 187)

interference of machine operation. The second is to place it so it can easily be reached for maintenance, preferably in such a manner that the entire unit can be removed and replaced without difficulty. This often involves the use of mechanical connections through levers or plungers to operate electric controls. A third factor cannot be stressed too highly—to keep controls away from hazardous areas but not to hide them inside of the machine where they are inaccessible.

The use of a simple mechanical connection as outlined is illustrated in *Fig.* 3. In addition it also shows the manifold mounted limit switch frequently used to simplify maintenance. It is wired through a hole in the rear of the switch which is sealed by a neoprene gasket on the rear cover. The switch can be changed without touching any conduit, reducing down time and eliminating a common maintenance error: failure to reconnect the conduit to its limit switch after replacement.

Following the previous principles may also require separation of solenoids from the parts they actuate and the use of a simple mechanical connection. The mounting illustrated in *Fig.* 4, is for a solenoid separated from the hydraulic valve it operates. This provides the advantage of separate maintenance for the electrical and hydraulic components and protects the solenoid in a separate oiltight compartment.

Since the replacement of control equipment mounted on machines is greater than that of panel-mounted equipment, proper identification of such units is of great importance. Our policy regarding tags on machines is guided by the rule "You can't tell the man in the plant enough about your machine!"

Items such as machine-mounted solenoids should be identified not only by number but also by function. It is important that identification tags be attached to some part of the machine rather than to a piece of control equipment. This eliminates the possibility of losing

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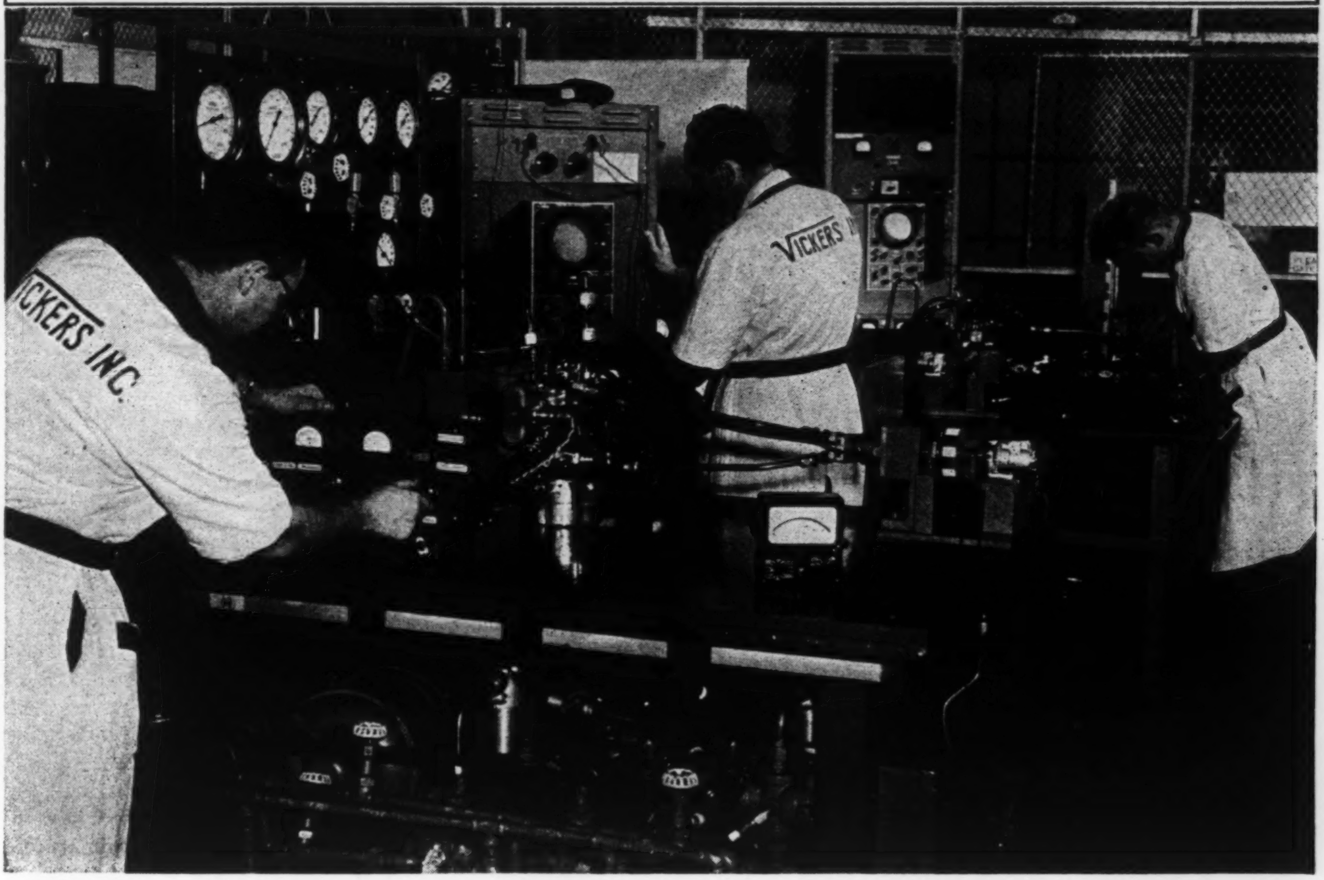

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the identification when the control equipment is removed for maintenance.

Control Wiring: Electrical design must also consider a third area in the control circuit and its relationship to the mechanical and hydraulic design consisting of the wiring. In laying out the wiring system for a machine tool, running from the various pieces of equipment in the machine to the panel-mounted controls, three factors are of prime importance:

1. All wiring must be protected in a manner consistent with its function and the hazards to which it is subjected.
2. It must be completely accessible for maintenance.
3. It should in no case interfere with the accessibility or maintenance of any of the hydraulic or mechanical components of the machine.

Considering the extreme conditions, two methods can be utilized for handling wiring on and around a machine. The first is in an overhead conduit or square duct away from the machine. This removes it from potential dangers such as oil, coolant and excessive dirt and is superior to running conduit around a machine at a low level because it eliminates the possibility of damage by maintenance men or industrial trucks. Its main disadvantage is that it may reduce accessibility to mechanical and hydraulic components of the machine because it is usually in the way.

The second method is to carry all the wiring in oiltight raceways in the machine components. If proper care is taken in the design of such mechanical components for the handling of wire, protection and safety as well as accessibility for easy maintenance is provided. Appearance with this method certainly is improved. However, great care must be taken in the design of raceways to insure accessibility and completely oil-tight construction. Identification of raceways will eliminate confusion with other machine compartments and is essential when this method of carrying wires is used. Both methods of wiring or a combination of the two have their place on machine tools.

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In the search for faster, better ways of digging out the earth's many mineral treasures, designers of mining machines and equipment are finding OSTUCO Tubing the ideal solution to countless problems.

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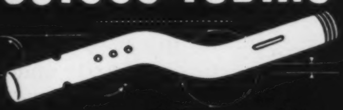

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Analysis of each job should be made early in the design stages to determine the wiring pattern.

System Diagrams: To complete the fully integrated hydraulic and electrical control circuit, it is necessary to provide both the manufacturing division and the prospective user with complete information regarding the controls used. This normally includes elementary and symbolic diagrams on both hydraulic and electrical circuits in addition to cycle descriptions. The type of description should enable a builder and maintenance man to get a complete picture of the overall cycle as well as of the separate systems.

From a paper entitled "The Coordination of Electrical, Hydraulic and Mechanical Elements in Machine Tool Design" presented at the 17th annual Machine Tool Electrification Forum sponsored by the Westinghouse Electric Corp. in Buffalo, N. Y., April 1953.

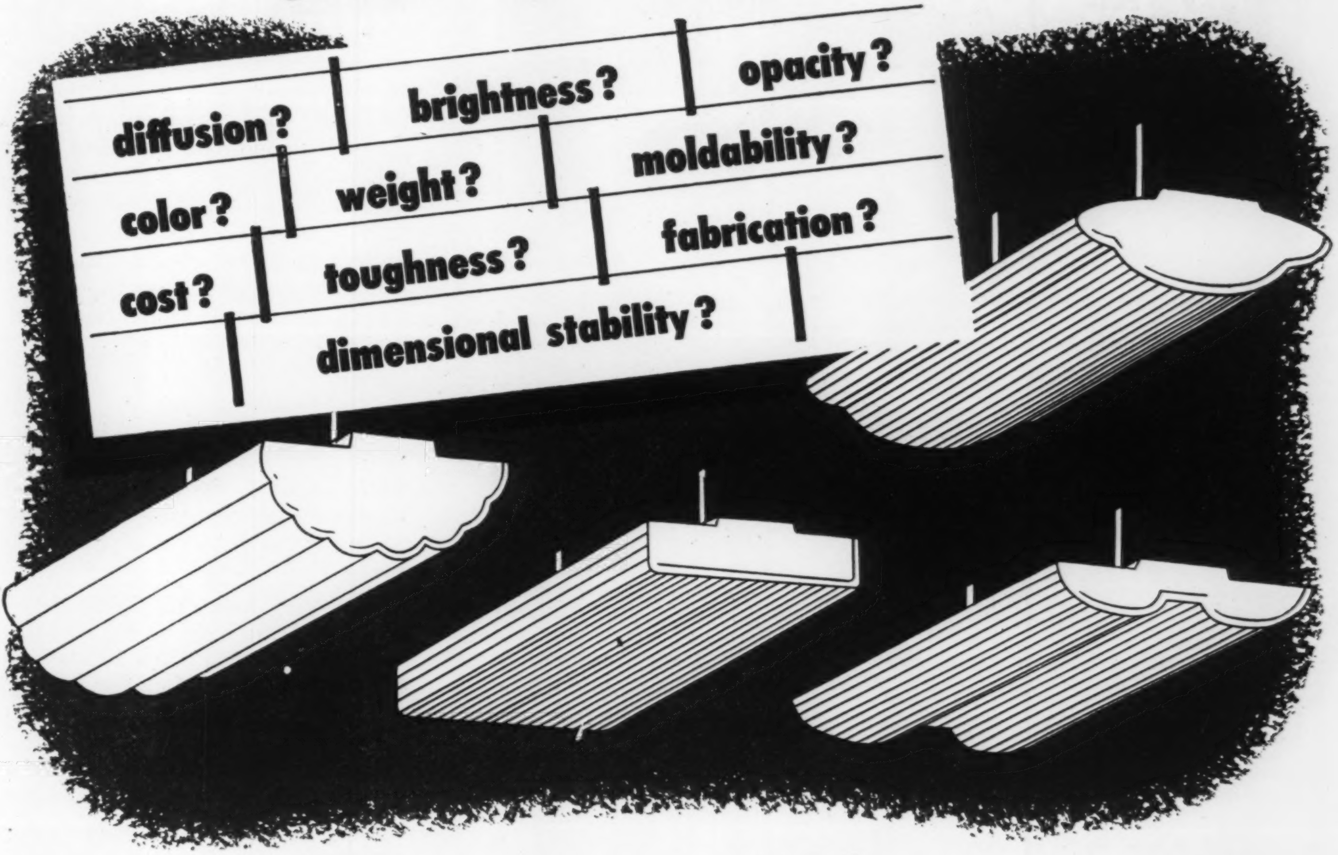
Resisting Corrosion with Titanium

By W. Lee Williams
Head, Physical Metallurgy Branch
U. S. Naval Engineering Experiment Station
Annapolis, Md.

IN RECENT years the technical press has been flooded with writings which sing praises about the corrosion resistance of titanium. One author summed up the general situation about as follows. In most corrosive chemicals, titanium and type 316 corrosion resistant steel run neck and neck with one important exception. Titanium is definitely superior to resistance to solutions of chlorine, chlorides and dilute hydrochloric acid. This fits in with the fine sea water resistance reported by others. In this environment titanium is even immune to the conditions which cause pitting of type 316 steel; stagnation, in crevices, under fouling organisms, and under moist salt crystals.

Application Factors: Of course, the engineer must look beyond

What's *your* lighting fixture problem?


diffusion?
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opacity?
color?
weight?
moldability?
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toughness?
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dimensional stability?

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"Evenglo" is optically superior because you can exercise more accurate control over opacity, diffusion and color in the finished product. In effect, you can specify the color tone of light, degree of brightness and amount of diffusion desired, and you can be sure your specification will be maintained exactly in each "Evenglo" panel, from first to last.

Koppers Polystyrenes 8X and 81 are the types normally used in formulating "Evenglo." Its high heat distortion temperature gives it a decided advantage over competitive polystyrenes. "Evenglo's" unrivaled combination of easy moldability, dimensional stability, light weight, ease of fabrication and low cost makes it a desirable choice over other plastics and glass.

Koppers application engineers will be glad to demonstrate the versatility of "Evenglo" Polystyrene and to recommend the "Evenglo" formulation that fits your specific requirements.

KOPPERS
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Write for New, Free Bulletin C-2-162

It contains technical data about "Evenglo's" physical and optical properties, and outlines the scope of its usefulness in the lighting field.

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SEALOL

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such general statements when he gets down to specific applications. He is sure to find numerous places where the corrosion resistance of titanium is not adequate. Nevertheless, one cannot escape the impression that titanium must be classed among our best and most versatile corrosion resistant engineering materials. It is probably safe to say that corrosion resistance will be a consideration, at least to some extent, in the majority of the applications for titanium and its alloys.

Experience shows that it is the exception rather than the rule for a machine or other item of equipment to be constructed of a single metal or alloy. From the simple to the complex, from household water systems to ships and airplanes, we find various materials used in combination. Thus, it is reasonable to predict that most applications for titanium will find it used in conjunction with other metals.

This brings us to the main point of our discussion. What will happen, and what can we do about it, if titanium and some other metal are used together in the presence of a corrosive medium which is an electrolyte? In other words, what about galvanic corrosion?

Precautionary Measures: The practical engineer wants to know, in simple terms, what he can do to remedy bad situations or head off troubles before they develop. Simple rules to minimize the effects of galvanic corrosion have been described by others and can be boiled down as follows:

1. *Select combinations of metals as close together as possible in the galvanic series.* For example, titanium and type 304 stainless would work well together, but the coupling of titanium and aluminum could lead to disastrous effects on the latter material.
2. *Avoid making combinations where the area of the less noble material is relatively small.* For example, a joint failure would occur many times faster with copper rivets in titanium plates than it would with titanium rivets in copper plates.
3. *Insulate dissimilar metals wher-*

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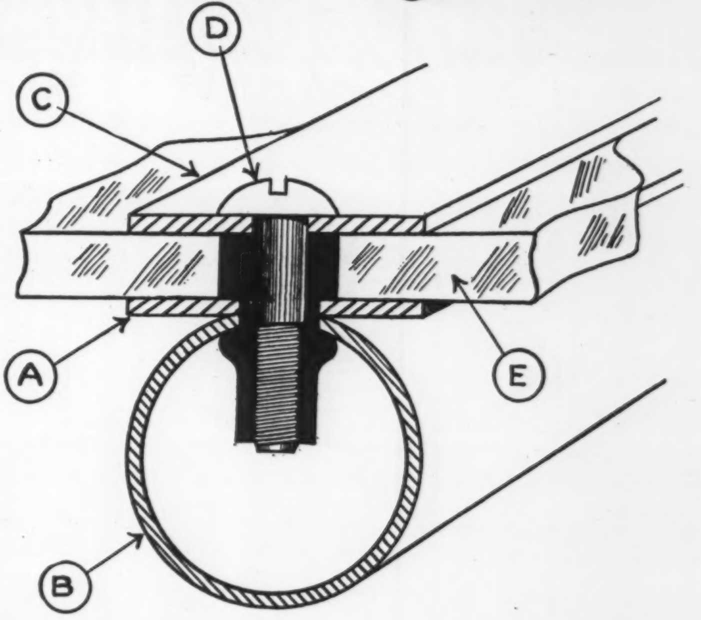
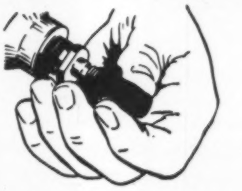
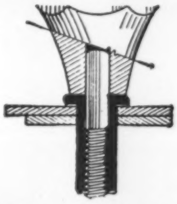
Besides providing a tight, dependable seal, Rivnuts saved many man-hours on this job. If you're looking for a fastener which can improve your product and cut production time, why not get the facts from a Rivnut engineer? Write The B. F. Goodrich Company, Department A - 35, Akron, Ohio.



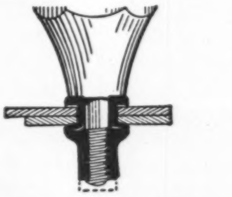
Rivnuts provide at least 6 clean threads in one simple operation!



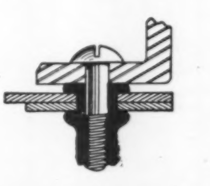
1 Rivnut is threaded onto pull-up stud of a manual or pneumatic heading tool.



2 Rivnut is inserted—head firmly against work—tool at right angles to work.

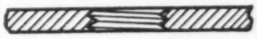


3 Tool lever operates pull-up stud, forming a bulge in the Rivnut shank.

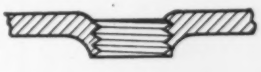


4 After upset, Rivnut threads are still clean and intact, ready for screw attachment.

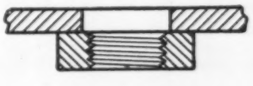
Compare these 4 methods of putting screw threads in thin sheet metal



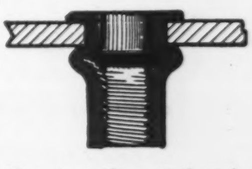
Tapped—2 threads



Pierced and tapped—3 threads



Projection welded—4 threads



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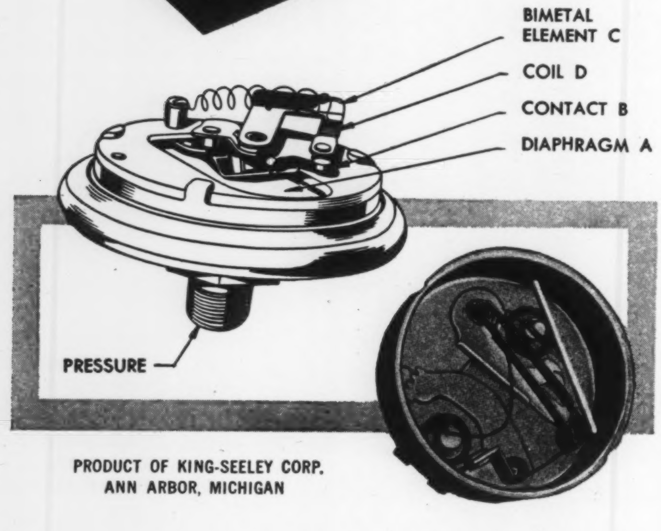
SEE HOW RIVNUTS WORK

CHACE BIMETAL DOES DOUBLE DUTY IN THE Telegage



PRODUCT OF KING-SEELEY CORP.
ANN ARBOR, MICHIGAN

This electric oil pressure "Telegage," manufactured by King-Seeley Corporation, illustrates a use of thermostatic bimetal known as the "double bimetal circuit." Diaphragm A is subjected to the engine oil pressure. The diaphragm movement forces grounded contact B against the insulated contact on the "U" shaped bimetal element C. As the current flows through the circuit, the coil D heats the element, causing it to bend back, opening the contacts momentarily. The bimetal cools in an instant and again the contacts close.

The dash unit encloses a similar bimetal element and coil. Since both heater coils are in the same circuit, a similar bending of the bimetal occurs and the linkage moves the needle accordingly. When oil pressure increases, the bimetal element C is heated more in order to open the contacts; and this same increased heat causes a greater movement of the needle.

Chace Application Engineers, recognized authorities on temperature responsive devices, are available for consultation on your problems in temperature-actuated devices. Chace Thermostatic Bimetal is available in 29 types in strips, coils, random long lengths and welded or brazed sub-assemblies. We invite you to write for our 32-page booklet "Successful Applications of Chace Thermostatic Bimetal," containing condensed engineering data.

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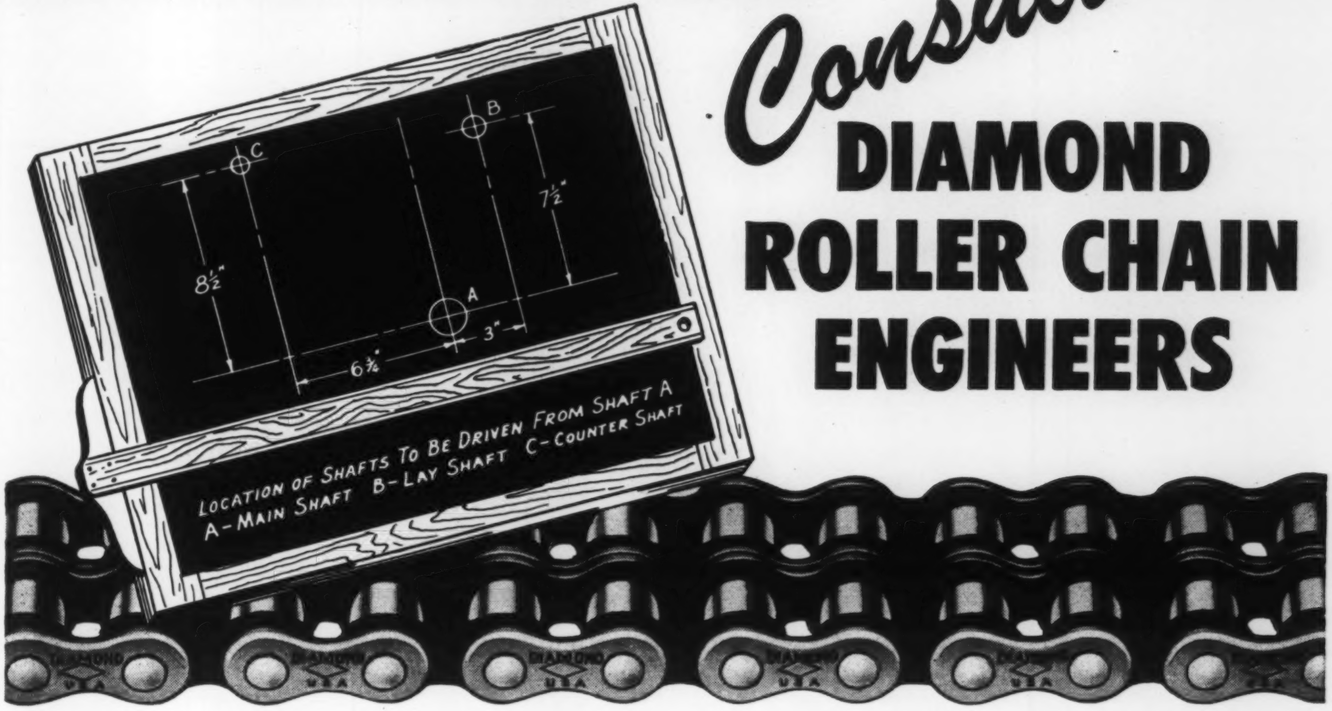
ever practical. If complete insulation is not practical, it will be helpful to use paint or plastic coatings at joints if the circuit resistance can thereby be increased appreciably.

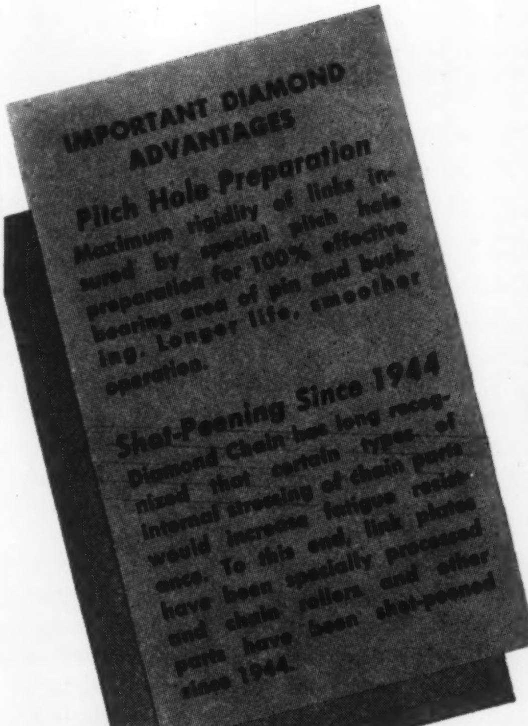
4. *Apply coatings on exposed surfaces with caution.* For example, do not paint the less noble material without also painting the more noble metal. Otherwise, greatly accelerated local corrosion can occur by concentrating the galvanic current at coating imperfections on the less noble metal. It follows that coatings should be kept in good repair.
5. *When dissimilar metals are located remote from one another, but are connected by an external conductor, design the equipment to keep the metals as far apart as possible.* The effect of this is to reduce galvanic current by increasing the resistance of the liquid path.
6. *If practical, add suitable chemical inhibitors to the corrosive solution.*
7. *Avoid joining dissimilar metals with threaded joints, if possible.* Threads are likely to deteriorate rapidly. Brazed joints are preferred, using a brazing alloy more noble than at least one of the metals to be joined.
8. *Provide protective galvanic current, either from an external power source or from zinc, magnesium or steel consumable anodes installed within the system.* These methods have been described in detail by other authors.
9. *Install replaceable waster pieces.* If galvanic corrosion cannot be prevented, it is often possible to install a section of less noble material at the joints where galvanic contact occurs. Thus, nearly all attack is localized and restricted to the replacement item. For example, heavy-wall steel nipples could be used between steel tubes and noble metal fittings in a piping system.

There is no doubt about the desirability of making corrosion resisting equipment of a single material throughout. However, this is seldom achieved in practice. The simultaneous use of dissimilar metals is a much more common occurrence. Nevertheless, the engineer who pays heed to the few simple rules outlined will rarely

WHEN DESIGNS AND REDESIGNS ARE ON THE DRAWING BOARD—

Consult DIAMOND ROLLER CHAIN ENGINEERS


C
B
A
8½"
7½"
6¾"
3"
LOCATION OF SHAFTS TO BE DRIVEN FROM SHAFT A
A-MAIN SHAFT B-LAY SHAFT C-COUNTER SHAFT
DIAMOND
U.S.A.



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find himself in serious trouble from galvanic corrosion. Although titanium is cathodic to most of the common constructional materials, the galvanic corrosion problems associated with its use are not different from the problems encountered with such well known alloys as monel and stainless steel.

From a paper entitled "Utilization of Titanium and Other Alloys in Corrosive Environments" presented at SAE Annual Meeting in Detroit, Mich., January, 1953.

Evaluating Gear Lubrication

By V. N. Borsoff and S. S. Sorem

Research Engineers
Shell Development Co.
Emeryville, Calif.

MANY of us are accustomed to thinking of gears as highly reliable and efficient power transmitting mechanisms. This attitude is justified by an almost complete absence of gear problems in the machines with which most of us have day-to-day contact. However, when an attempt is made to reach the maximum economy of weight and materials, a number of potential problems arise. Some of these problems will be initially evident as gear failures. Others will first appear as operational disorders which if not corrected will lead to gear failures or some other maloperation of the unit.

Gear Failure: Types of failure are subdivided here into six main classes: (1) tooth breakage, (2) pitting, (3) scoring, (4) abrasion, (5) chemical wear, and (6) corrosion. It is true that the literature recognizes many more types of gear failures. The American Gear Manufacturers Association, for example, lists twelve. However, these more detailed subdivisions include descriptions of conditions resulting from a combination of causes and of secondary effects initiated by some primary failure, and are omitted here.

Tooth breakage is a mechanical and fatigue phenomenon, depending on the magnitude of the load, the

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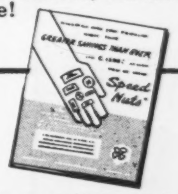
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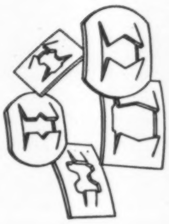

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number of cycles, strength of the materials and the tooth form. In designing for tooth strength, the Lewis equation is generally used.

Pitting is primarily a surface fatigue phenomenon and also depends on magnitude of the load, number of cycles and the strength of the materials. It has been found that to some extent pitting can be alleviated by shot-peening and operation with more viscous lubricants. Apparently a thicker lubricant film prevents heavy stress concentrations and so minimizes pitting.

Abrasion and scoring are surface phenomena and represent a failure of lubrication. The lubricating film must have broken down, at least partially, to make these failures possible. Abrasion takes place when the lubricating film is too thin to prevent the cutting action of projecting asperities, but is too strong to be displaced and permit scoring.

Chemical wear is encountered when extreme pressure type additives are used in a lubricant to counteract scoring. These additives function by reacting with the metal of the gear tooth surfaces to form a protective film less readily displaced than oil. However, when this film performs its function a portion of it is lost by attrition and is replaced by further reaction. This loss and replacement of the film gives rise to chemical wear. In most cases, chemical wear is too slow to affect gear performance within the normal life of equipment. However, this is not always true. The case of case-hardened gears sometimes becomes thin enough, as the result of chemical wear, to permit distortion due to flow of the underlying softer metal. Failures called "rippling" or "fish-scaling" are of this type.

Mechanical Improvements: The study of these failures reveals that both speed and load affect them all adversely. It is therefore the aim of gear designers to design gears for given operating conditions with minimum sliding velocity and with the lightest possible specific load. Earlier gears were inaccurate, they "cogged" and "jammed," i.e., they

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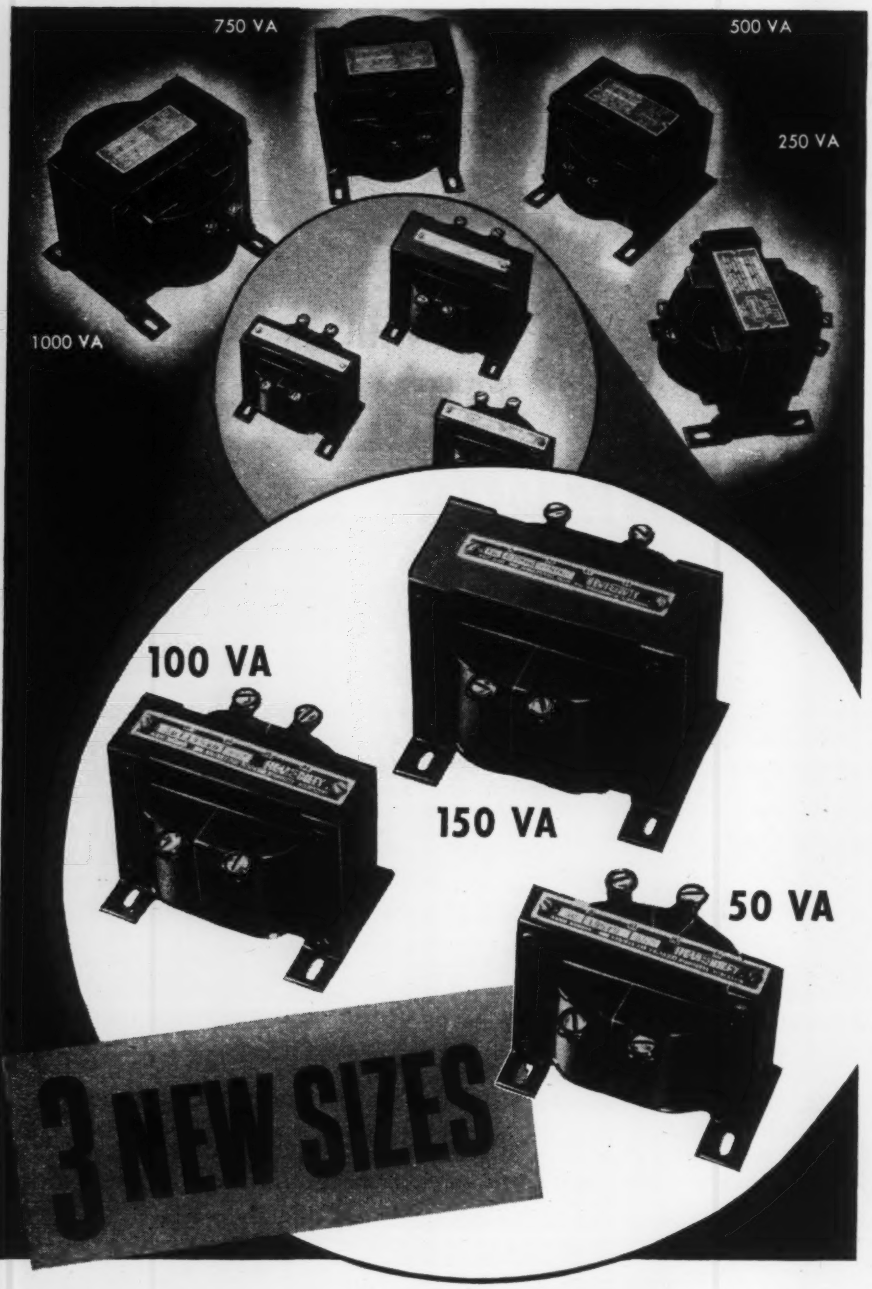

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transmitted motion in an irregular, jerky manner, and the teeth were subjected to dynamic loads in addition to the transmitted torque load. To overcome this, many forms of conjugate gear tooth action were developed. The involute form is the most extensively used today.

From the standpoint of kinematics, which deals with motion only and excludes the concept of force, the involute form is ideal since it maintains a constant angular velocity ratio between mating gears. From the standpoint of tooth contact pressure and rubbing velocity, it leaves much to be desired. With the involute form, the sliding velocity is zero at the pitch circle and increases sharply toward both the addendum and dedendum. To minimize its maximum value the gear designer will choose the smallest possible tooth that will carry the required load. The smallest possible tooth is also desirable from the standpoint of the tooth contact pressure which depends on the radius of curvature and increases with the distance from the pitch circle.

Contact Ratio Influential

To some extent the load at the point of highest sliding velocity is further decreased by tip relieving the addendum and undercutting the dedendum. Still, on the involute profile, conditions are most severe on the addendum and dedendum as shown by the fact that scoring and other wear failures almost invariably occur first at these points. The load also depends on the contact ratio, which in the present designs with straight gears is usually less than two. This means that the transmitted torque for a part of the time is carried by one pair of meshing teeth only. The contact ratio is sometimes improved by employing oblique designs.

The unfavorable effect of speed and load does not end with the variations along the active profile. With production gears operating at high speeds, the irregular transmission of motion, though not so obvious, is still a factor to be considered in determining the total load acting between gear teeth. We are accustomed to thinking of load as that caused by the transmitted torque. This is the so-called "applied" load. On top of that there are "additional" loads caused by tooth deflection and various inaccuracies and errors, such as runout error, pitch error, profile error, etc. These additional loads, according to Professor Buckingham vary as the square of the velocity and at high speeds they reach dangerous proportions. A high degree of accuracy in manufacturing is the only possible relief from these loads. The American Gear Manufacturers Association specifies tolerances for Class 4 gears (over 2000 fpm) up to 0.0002-in. For the gears of tomorrow, operating up to 20,000 fpm, even finer tolerances may be required.

Surface Improvements

Other mechanical approaches which have resulted in improved gear performance are improvements of gear material, heat-treating processes and surface finish. Generally, manufacturing gears from tougher and stronger materials will result in better preservation of geometry and surface finish. Comparison of the materials used in the past with those used today verify this. Regarding surface finish, the general tendency is toward a high degree of smoothness, one effect of which is to spread the load more uniformly over the contacting surfaces, thus minimizing peak loads at asperities.

Operational disorders can also be alleviated by mechanical means. In the case of overheating, Collins has shown that surface finish is an important factor in the production of heat. Much can be done also in the removal of heat by providing an excess of lubricant to act as a coolant.

Foaming problems can frequently be eliminated by rearrangement of the lubricant circulating system to minimize the mixing of air with the lubricant and by providing separators to aid in the removal of air that does become entrained.

There are, however, practical limits to the improvements which

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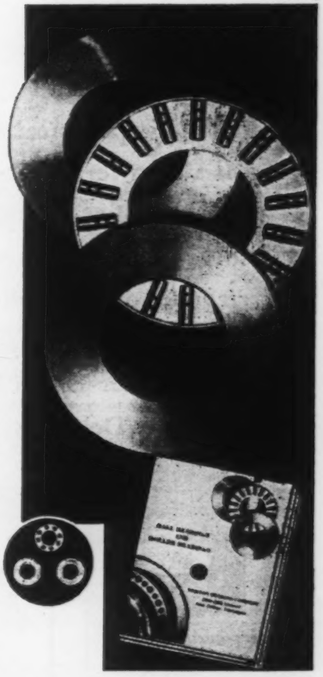

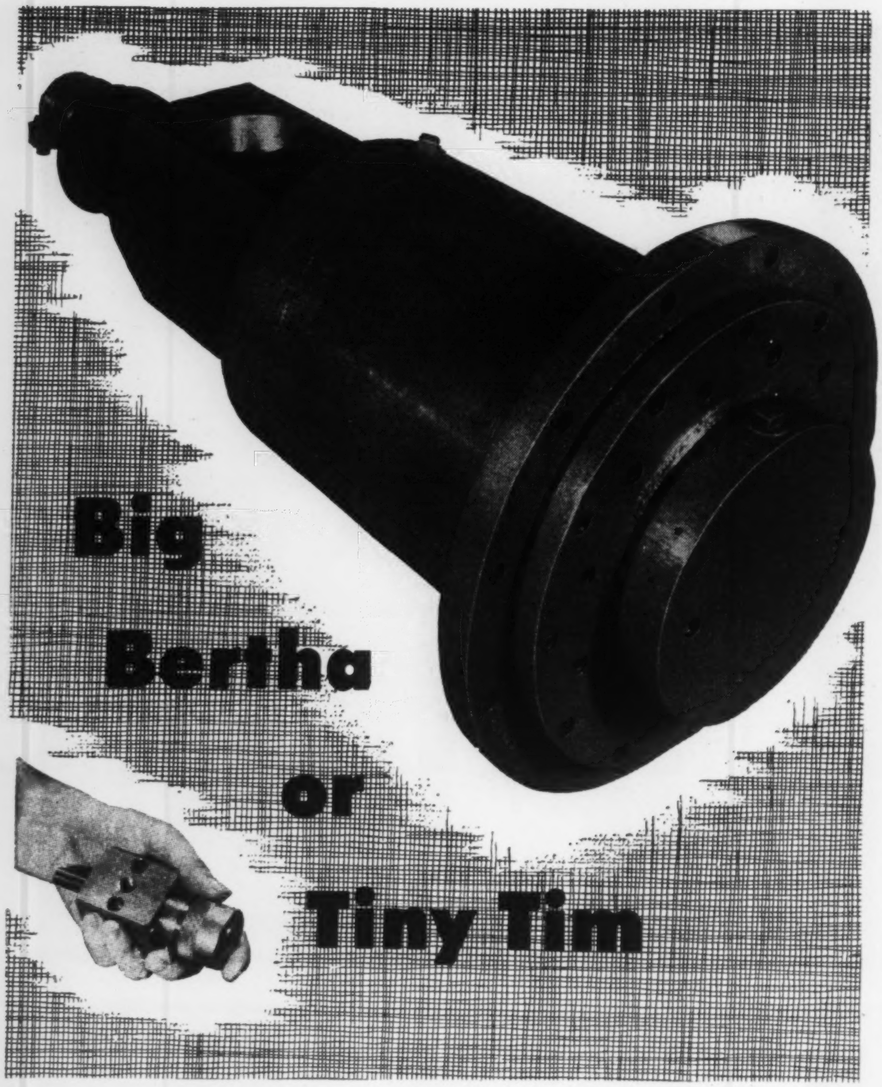

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can be made in gear accuracy, geometry, material and finish. For example, it is hard to visualize a gear set being cut, assembled and operated without some tooth errors in excess of 0.0001-inch. Thermal and mechanical strains and wear of supporting shafts, bearings and structure practically prohibit going further mechanically. Thus for further progress the job of maintaining satisfactory operation and preventing failures must be assumed by the lubricant.

Lubrication Factors: In the history of gears there are examples where lubricants literally saved the situation. In the twenties hypoid gears were developed. Notwithstanding the advantages they offered, particularly for automotive applications, they were at first considered unoperative because of the scoring that inevitably resulted upon application of their design load. The introduction of extreme pressure lubricants saved these gears, and now loads from ten to twenty times those obtainable with uncompounded lubricants are successfully carried.

Most of the improvements in gear lubricants to date have been the result of a qualitative approach to the chemical and physical-chemical problems involved. To produce films less readily displaced than hydrocarbon oils for the purpose of extending the region of boundary lubrication, three approaches appeared theoretically possible: (1) the addition of polar compounds which would be absorbed on the gear teeth, (2) the addition of unstable materials which would decompose and deposit a tenacious film under gear tooth conditions (leaded oils) or (3) the addition of compounds containing chemically active ingredients such as chlorine, sulphur or phosphorous (EP oils) which would react with the gear tooth surface forming a lubricating film in situ. All of these approaches have been effective in some applications. The first two have been found best suited to bronze on steel worm gears where they give very appreciable increases in load carrying capacity. For heavily loaded steel-on-steel gears,

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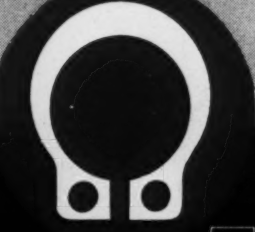

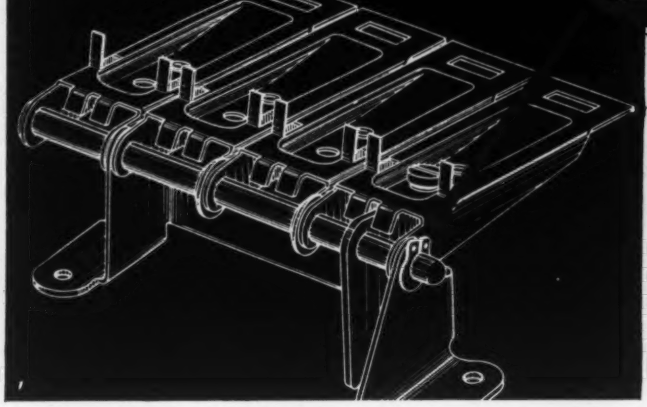

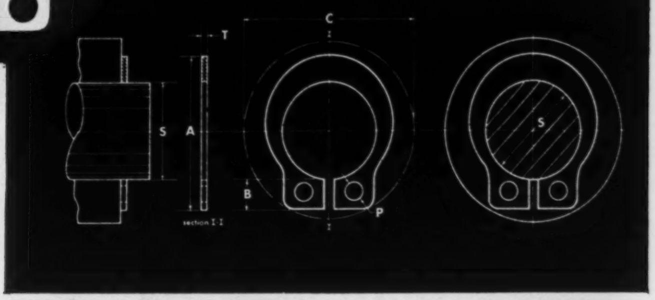

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RING DIMENSIONS	Thickness T	.025	.025	.035	.035	.042	.042
	Thickness TOL.	±.0015	±.0015	±.002	±.002	±.002	±.002
	Length A	.268	.285	.364	.437	.553	.626
	Lug B	.078	.078	.097	.097	.141	.141
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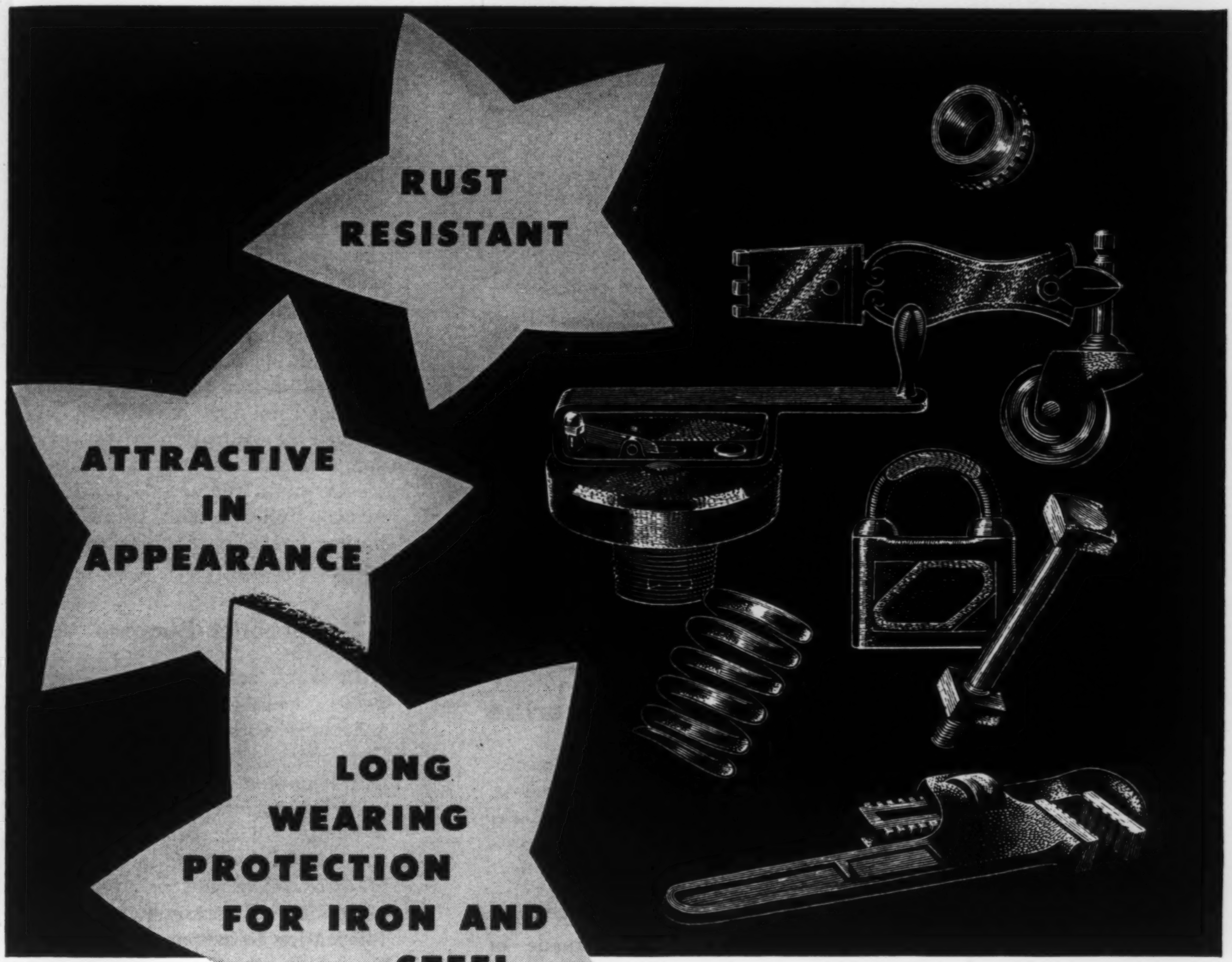
the chemically active extreme-pressure oils are the more successful. Many of these compounds gave extraneous reactions in use, leading to corrosion, deposit formation and rusting. Various test procedures had to be set up to detect these potential difficulties and eliminate offending materials. A number of such test procedures will be found listed in the MIL-L-2105 gear lubricant specification.

The effect upon the lubricant of overheating has been reduced by suitable selection and treatment of the base lubricant, by the use of oxidation inhibitors and, more recently for special application, by the replacement of mineral oil base materials with synthetics of considerably greater stability. This has been strictly a chemist's problem.

Foam, although of mechanical origin, has been greatly minimized as a gear lubrication problem by the introduction of additives which reduce the stability of foam once formed. Corrosion problems have been taken care of principally by avoiding additives that produce corrosive materials by undesirable side reactions though a number of buffers and corrosion inhibitors are known and used.

Lubrication Theory: All together these mechanical and lubricant improvements have resulted in tremendous strides in the art and science of power transmission through gearing. However, much further progress appears possible. To facilitate this progress, quantitative information relating the power transmitting capacity of a gear set to the physical and chemical characteristics of both the gear and its lubricant is needed. As a first step in this direction the mechanism of gear lubrication must be thoroughly understood.

Classical lubrication mechanism studies with steady-state systems, such as a journal bearing, show the existence of two zones of lubrication, called the hydrodynamic and the boundary zones. In the hydrodynamic or thick-film zone, a film of lubricant exists sufficiently thick to prevent contact of even the highest asperities of the rubbing surfaces.



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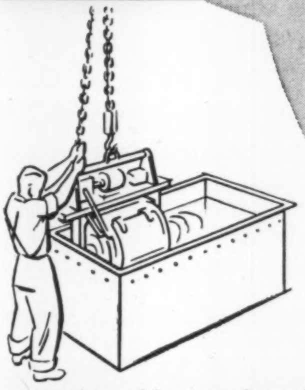

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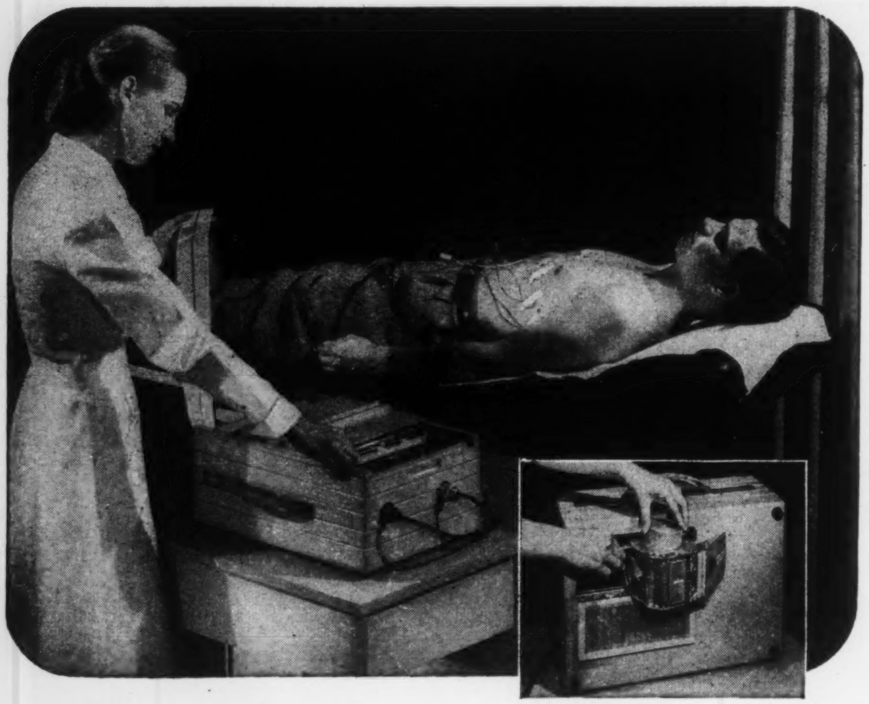

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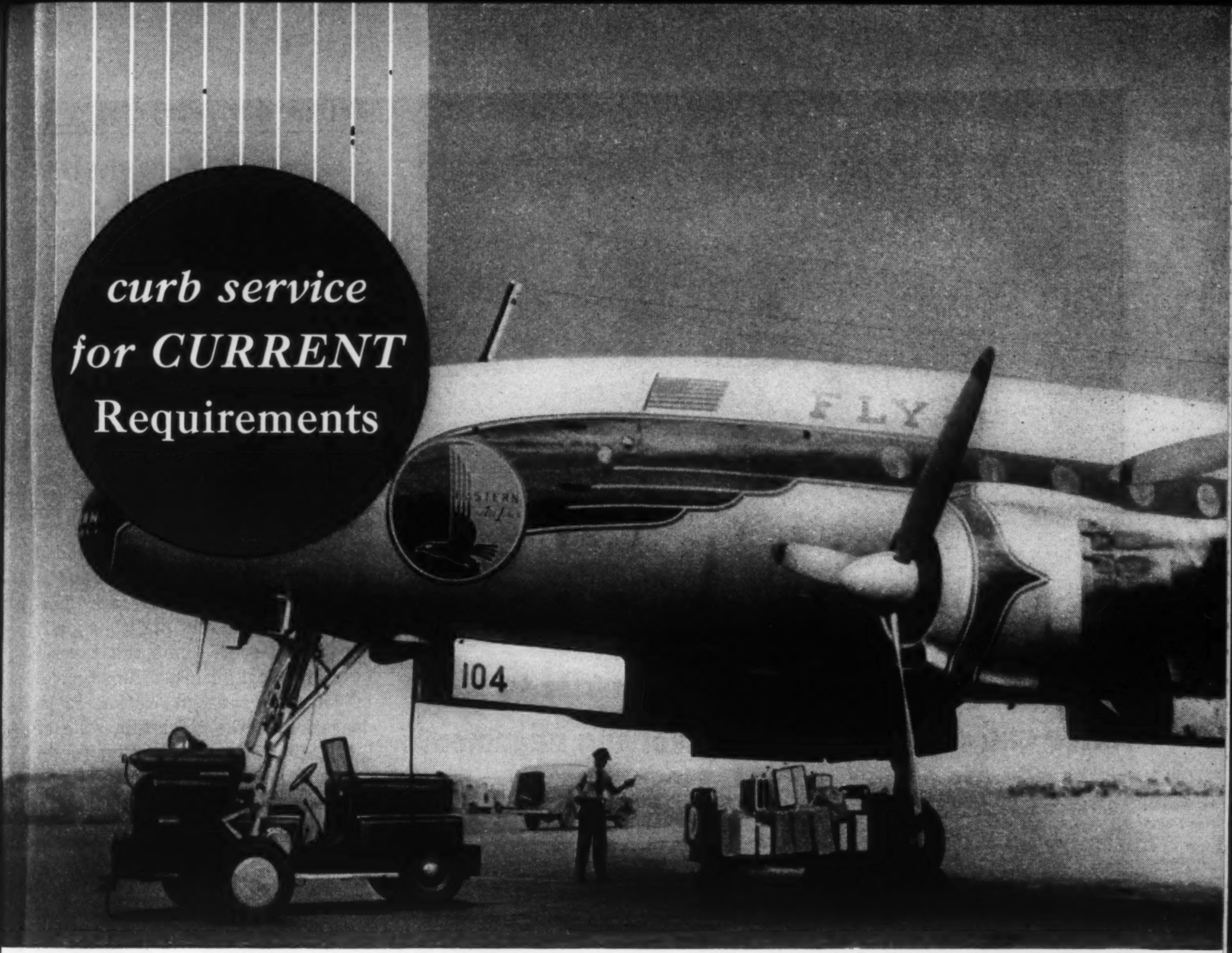
The film pressure integrated over the bearing area is equal to the total load and can be calculated for these simple systems. In this zone of lubrication, friction is low and wear is virtually absent because of the absence of contact between metal components. When the load exceeds that which can be supported by hydrodynamic pressure, lubrication is said to be in the boundary or thin-film zone. A portion of the load is now carried on films formed by adsorption or reaction of some constituent of the lubricant on the metal surfaces. Lubrication in this thin-film zone gives rise to higher coefficients of friction and to some wear.

Theories Disagree

In what zone of lubrication do gears operate? There are two schools of thought on this subject. One believes that gears operate in the boundary zone of lubrication and that formation of thick film is unlikely. The other recognizes thick-film lubrication in the regions of light loads and believes in the possibility of extending thick-film lubrication to extremely high loads. To decide which of these two theories is correct, it would be necessary to know precisely the tooth contact pressure and the supporting hydrodynamic pressure, neither of which is readily determined on meshing teeth. The contact pressure is the sum of the transmitted torque and dynamic forces which are functions of speed and the deviations from the perfect tooth form resulting from errors and deflections.

Supporting hydrodynamic film pressure is a function of speed, fluid viscosity and density, and the shape of the surfaces forming the film boundary. Fluid properties vary with pressure and temperature, and the film boundaries may be significantly affected by elastic and thermal distortions and profile errors. Because of the interdependence of so many variables and the cyclic nature of the meshing gear system, the mathematics describing the conditions of gear tooth lubrication become extremely involved even with many simplifying assumptions. It



curb service for CURRENT Requirements

Photo courtesy Hobart Brothers Company, Troy, Ohio

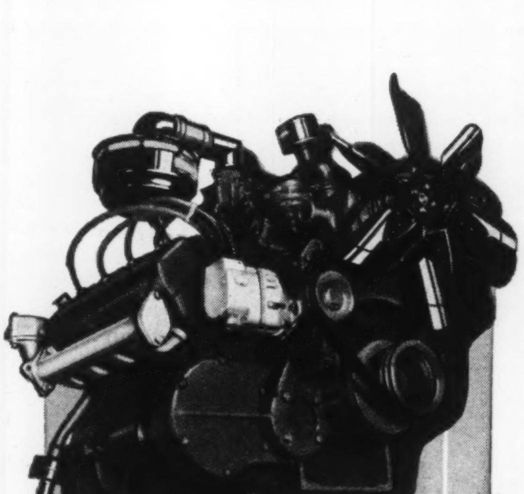
Chrysler horsepower on the ground for added Safety in the Air . . .

The moment the big plane stops and the pilot cuts the engines, the generators, which in flight supply electrical power to the batteries, stop too. But the electrical equipment in the plane—air conditioning, lights, radio, food containers, everything electrical—continue operating off the plane's batteries. Only for a moment, however. In that length of time a self-propelled and self-powered energizer takes over and supplies all necessary current, even starting the plane's engines when it's time to leave.

Among the most popular mobile ground power units are the "Power-Pull" units manufactured by Hobart and powered by Chrysler. The unit pictured uses the mighty 180 horsepower Chrysler V-8 Industrial Engine and can furnish 1000 amperes, 28.5 volts of direct current under continuous operation—enough to handle the electrical load of the largest aircraft. Power from the same engine propels the unit, enabling it to serve also as a towing tractor.

This is another in the long list of important uses of Chrysler Industrial Power. Whether your equipment requires V-8 or Six cylinder engines, Chrysler can supply them with gasoline, propane or natural gas burning carburetor, 3, 4 or 5-speed transmission and other optional equipment.

For your power needs, see a Chrysler Industrial Engine Dealer, or write: **Dept. 56, Industrial Engine Division, Chrysler Corporation, Trenton, Michigan.**



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HORSEPOWER **WITH A PEDIGREE**

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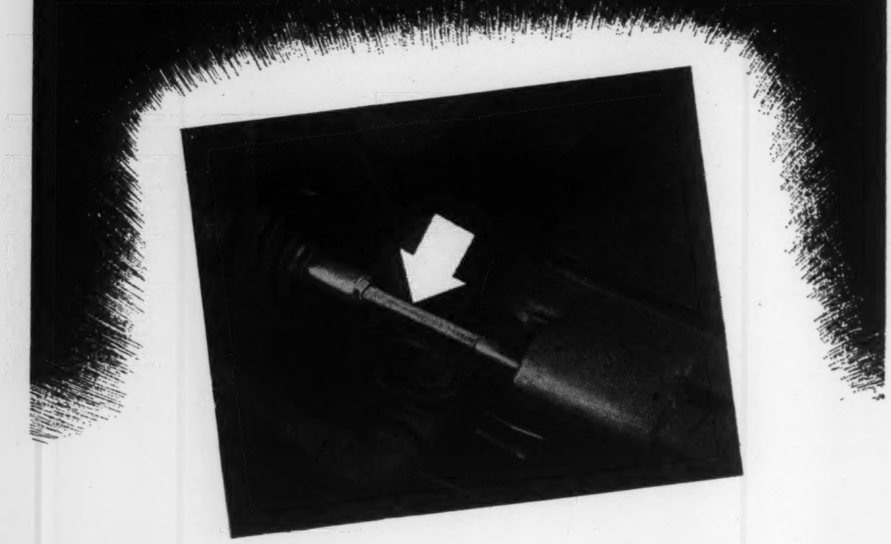


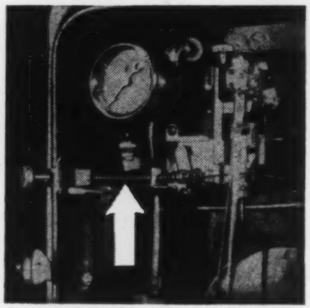
...the time-and-money-saving answer to drive and control problems involving alignment

Shown here are a few of the many ways in which designers are using S.S.White flexible shafts to lick alignment problems — on remote control and power drive applications.

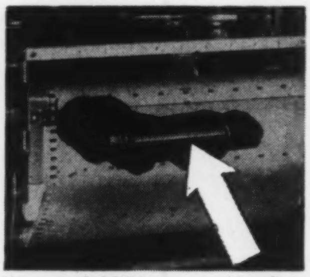
In cases like these, the shafts **completely eliminate the need for accurate alignment,** making possible major design improvements and **substantial reductions in manufacturing and assembly costs.** The non-rigid construction of the shafts automatically compensates for misalignment — absorbs shock and vibration — and simplifies assembly and machining operations.

Built up of tension-wound layers of special grades of wire, S.S.White flexible shafts possess amazing strength and flexibility. In performance they operate as easily, as smoothly and as dependably as a direct connection.

Take advantage of the cooperation of S.S.White engineers in applying flexible shafts to your needs — there's no obligation.



A control problem that was readily solved by a short length of S.S.White remote control flexible shafting.



Using an S.S.White power drive flexible shaft to couple a motor to the operating mechanism solved this alignment problem.

WRITE FOR THE FLEXIBLE SHAFT HANDBOOK

It contains 256 pages of information on flexible shaft selection and application. Copy sent free if you ask for it on your business letterhead.

THE S.S.White INDUSTRIAL DIVISION
DENTAL MFG. CO.
Dept. 4, 10 East 40th St.
NEW YORK 16, N. Y.

Western District Office • Times Building, Long Beach, California

was obvious that new research techniques were required to resolve even this fundamental question; in what zone of lubrication do gears operate? Radioactive tracers have provided an answer to this question, and in addition have been found extremely useful in the study of gear wear in operation with chemically active lubricants.

The results indicate that gears, when lubricated with a straight mineral oil, operate in the thick-film zone of lubrication up until the score load is reached. Also, gears lubricated with oil compounded with EP agents operate in the thick-film zone up to the score limits of their base oils, and that loads above this score limit are carried by a chemical adsorbed film typical of boundary zone lubrication. Since operation in the thick-film zone of lubrication offers many advantages —smaller friction, lighter pitting and practical elimination of wear— both gears and gear lubricants should be designed to operate in the hydrodynamic zone of lubrication as a goal of ideal operating conditions.

While the results thus far do not provide the gear designer with an equation into which he can plug values of gear and lubrication variables and work out a gear transmission giving a 100 hr, 1000 hr or 10 year life, it has resulted in the development of research tools which will permit substantial progress in that direction.

From a paper entitled "Effect of Lubricant on Gear Performance" appearing in the Iron and Steel Engineer for February 1953.

Analyzing Sleeve Bearing Failures

By B. P. Robertson
Sales Technical Division
Humble Oil and Refining Co.
Houston, Texas

FUNDAMENTALS of lubrication theory and their application to bearing design were well established long before the last World War. During the past ten years, however, the practical limits of lu-

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Synthane bushings, spacers, and bearings in the landing gear of this giant of the skies share the landing shock loads of twenty-five tons. But Synthane parts have many virtues in addition to their ability to withstand the jolts of heavy landings.

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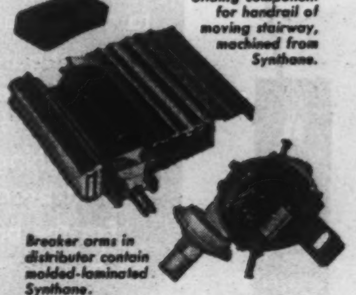
IS YOUR ANSWER HERE?

If you are not in the aircraft industry, Synthane's combination of properties may still stir your interest. Besides the properties at the left, Synthane has good tensile, compressive, flexural, impact and shear strength, a low coefficient of expansion, is moisture- and wear-resistant, easy to machine.



Sliding component for handrail of moving stairway, machined from Synthane.

Breaker arms in distributor contain molded-laminated Synthane.

Synthane-one of industry's unseen essentials

SYNTHANE

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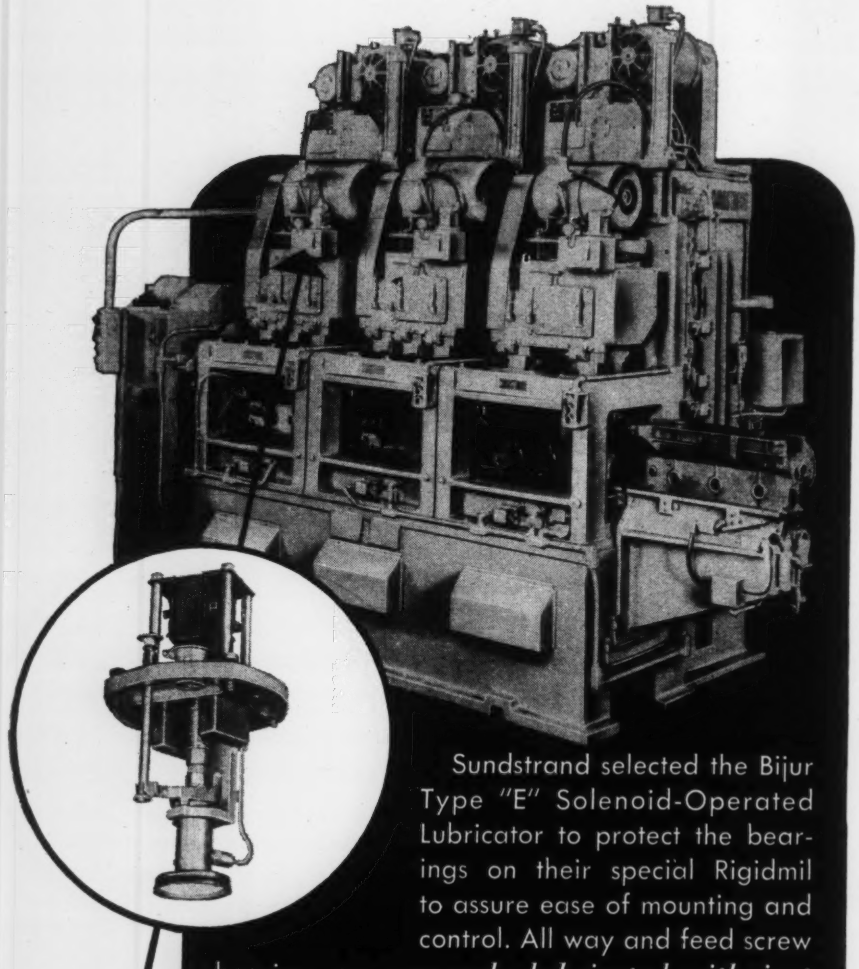
LAMINATED PLASTICS



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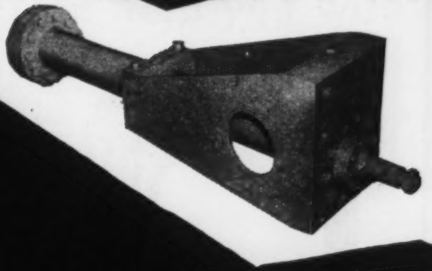
brication experience have broadened greatly. Development of new machines and new industries has required better bearings, better lubricants, and more skillful designs. An occasional review of bearing failure should, therefore, be of interest to those concerned with the design as well as the operation of mechanical equipment.

Bearing Failure: The causes of bearing failure might be classified in the following manner:

1. Normal service. Friction wear, abrasion, and load factors gradually lead to some fixed service life expectancy even under ideal conditions.
2. Mechanical or fatigue failure. Overloading, overspeeding, and improper installation result in this type of failure.
3. Corrosion. Oxidation of the oil contributes to corrosion and is increased by unstable oil, excessive temperature, poor selection of bearing material, or the presence of contaminants.
4. Inadequate lubrication. This normally results from deficiencies of the lubricant, contaminants present in the oil, and inadequate lubricant supply.
5. Incorrect clearance. Frequently this is caused by wrong insert size, improper crush, and improper tightening of bearing caps.
6. Improper installations. Out-of-round journals and housings, distorted frames, misassembly, rough housing bore, presence of dirt and chips in housing bore, and other factors are frequent causes of bearing failure.
7. Defective bearings. These result from poor bonding, porous or cracked bearing metal, and segregation of alloy metals.

It should be noted that only two of these causes of bearing failure are directly charged to the lubricant and only one to the bearing itself. Even in those instances there is an overlapping of responsibilities that usually makes it difficult to determine the cause by the examination of failed bearings.

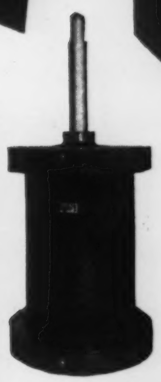
Unfortunately, most bearing failures are accompanied by excessive temperature that tends to reduce the bearings to a common appearance. When the lubricating



BIG CYLINDERS

LITTLE CYLINDERS

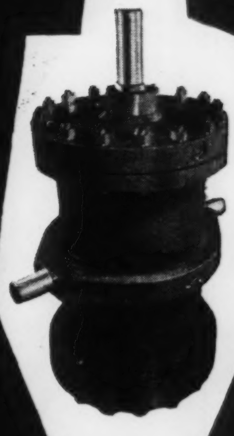
SPECIAL CYLINDERS



LINDBERG AIR CYLINDERS HYDRAULIC CYLINDERS

SHORT CYLINDERS

LONG CYLINDERS



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alloy: "600" series metal, a high strength bearing bronze that contains no tin

quantity to date: over 2,000,000

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advantages: no bearing insert is necessary on either the wrist pin or crankshaft end because each rod acts as its own bearing. Dense homogeneous grain structure, close dimensional tolerances and high mechanical properties often permit redesigning for weight savings as high as 15% to 25%. "600" alloys have low coefficient of friction, high resistance to corrosion and tensile strength 2½ times greater than cast phosphor bronzes.

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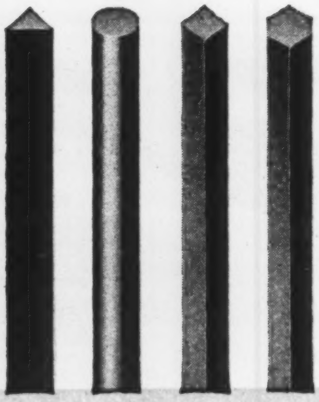
"600" SERIES ROD is produced in standard 12-ft. mill lengths and a wide range of sizes and special shapes. This rod has a fine, uniform grain structure and the mechanical properties are rigidly controlled in the cold drawing process. Scrap loss is greatly reduced in machining operations because of the complete absence of defects. For complete information, write us today.



MUELLER BRASS CO.
PORT HURON 15, MICHIGAN

film is destroyed by failure of the lubricant supply; by corrosive, fatigue, or abrasive damage to the surface; by improper clearance; or by improper installation, temperatures may rise rapidly to the melting point of the bearing metal. The same may occur as a result of excessive operating speed, the use of too viscous an oil, overloading, poor design, or defective bearings. Once the bearings have been badly overheated, it may be impossible to determine the real cause of failure by bearing inspection alone.

Fatigue Failure: Most bearings are subjected to cyclic loads produced by reciprocating or unbalanced rotating parts. In such an application where lubrication is adequate and filtration is sufficient to prevent abrasive wear, the useful service life of a bearing is normally ended by the appearance of fatigue patterns. Because of this association with normal service life and because of the importance of fatigue, particular attention will be given to this type of failure and to some of the factors that influence it.

Bearing fatigue occurs just as with other metal parts. The continuous reapplication of heavy loads eventually causes the metal to weaken and fail. Increasing the magnitude of the load or increasing the number of times the load is applied will cause earlier failure. Amount of load plus the element time are the important factors with respect to fatigue life. When the bearing is designed with plenty of excess strength in proportion to the work it must do, its service life will be long. If the work it is required to do just about balances its inherent strength, its natural life will be much shorter. As in all design, long life must be balanced against space limitations often under adverse service requirements. Automotive experiences testify for the good job that is normally done.

When correct oil drains, good filter maintenance, and proper driving habits are practiced, it is quite possible to realize 100,000 miles of service from a set of bearing inserts. Under like conditions where overspeeding, windmilling, detona-

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Custom Molded Rubber Parts

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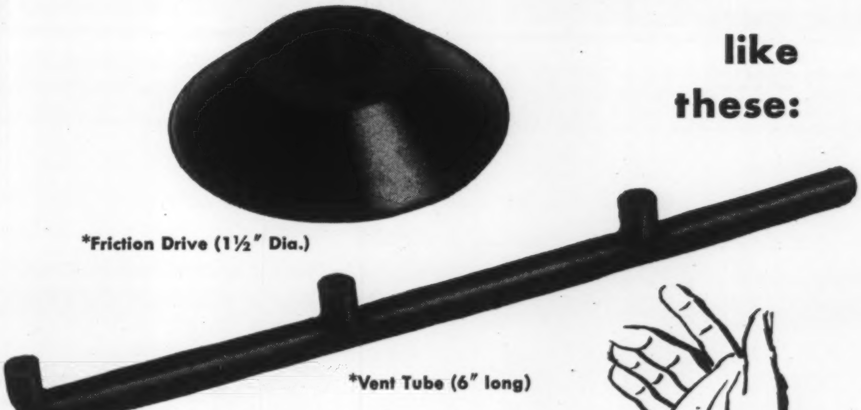

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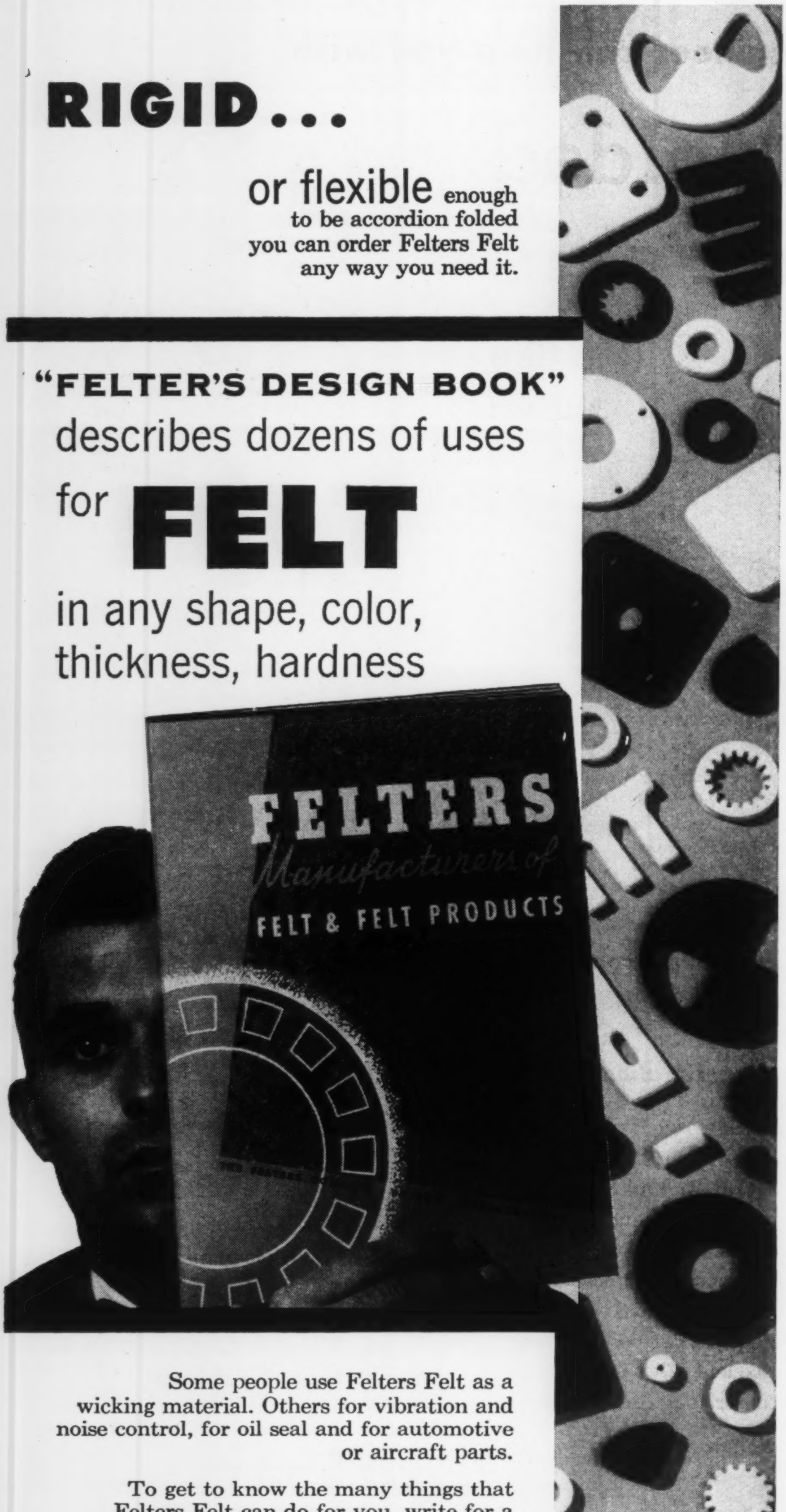

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tion and other service impositions are avoided, heavy commercial fleets may operate for 60,000 miles on a set of inserts.

Bearing Material: Many properties are important in the selection of a good bearing material. While these may vary with different applications, the average relative importance has been classified as follows:

Fatigue resistance	60%
Conformability	10%
Embeddability	10%
Antiscoring	5%
Corrosion resistance	5%
All others (heat transfer, etc.)	10%

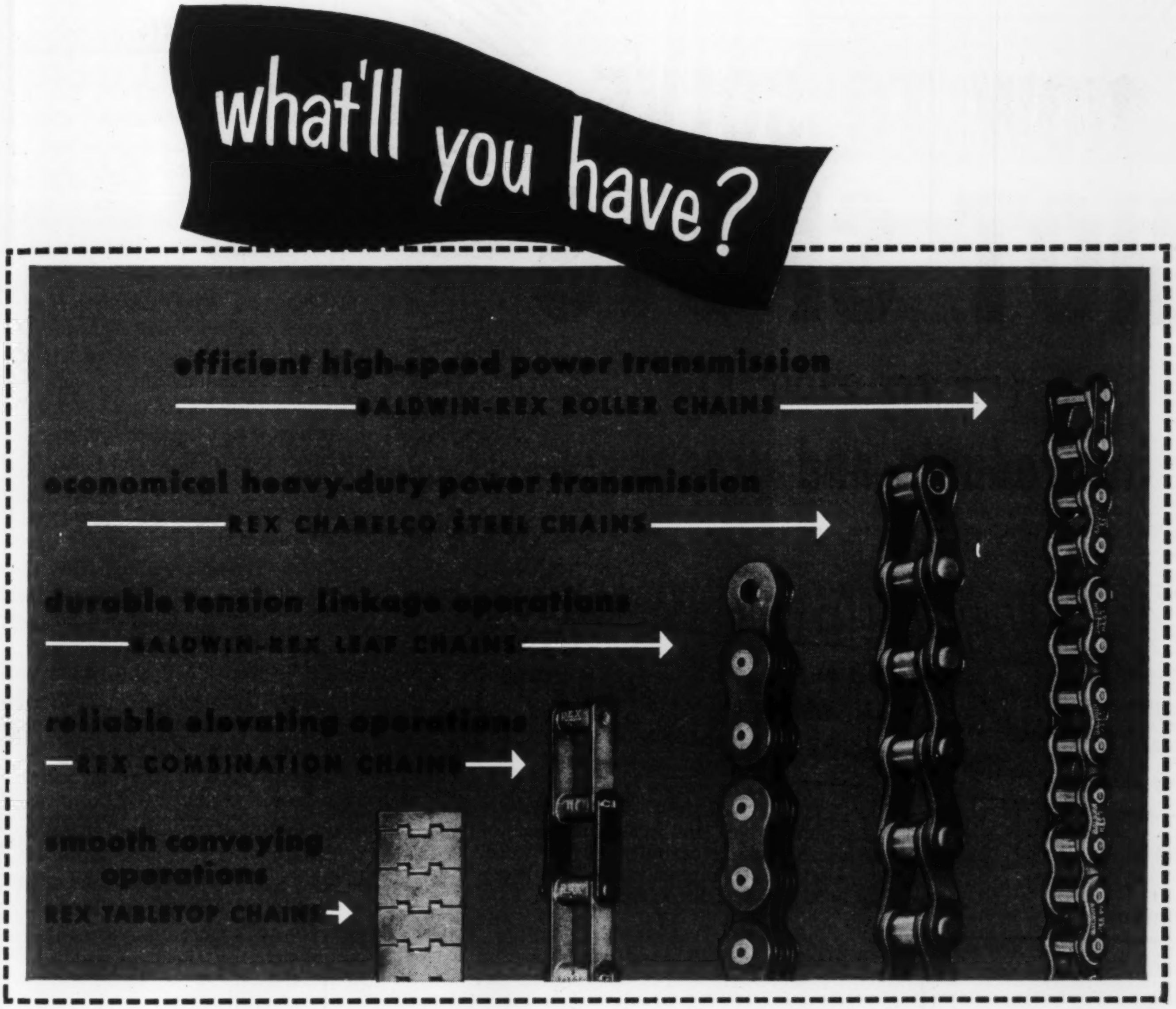
Since some bearing metals may be particularly strong in one property and weak in another, the design engineer must give particular attention to the special requirements of his design and the properties that they tend to emphasize:

Property	Excellent	Poor
Fatigue Resistance	Silver, Aluminum	Babbitt, Cadmium Alloy
Conformability	Babbitt	Copper-Lead, Silver
Embeddability	Babbitt	Silver, Aluminum
Anti-scoring	Babbitt	Copper-Lead, Silver
Corrosion Resistance	Aluminum, Tin Babbitt	Copper-Lead, Cadmium Alloy

While babbitt type bearing metal is excellent in most properties, it is unfortunately deficient in the most important—fatigue resistance. It in worthwhile to recall that the deficiency of metals may sometimes be remedied by overplating. For instance, a thin soft metal overlay may be used to greatly improve the conformability of silver bearings.

Fatigue Resistance: A test program evaluating the fatigue resistance of various bearing metals, as well as certain factors contributing to fatigue failure, may serve as a review of some interest. Also, the results serve to indicate the manner in which bearing and lubrication knowledge is broadened into new limits through the development of new applications.

Early stages of gas turbine development in this country brought new problems. This presented a new form of prime mover some-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WHAT can it do?	Resist thermal shock, withstand oxidation and abrasion, retain great strength at high temperatures (1800°F and above).
WHERE is it in use?	Successful applications include: Valves, valve seats, reduction crucibles, anvils for spot welding, hot extrusion die inserts, bushings, thermocouple protection tubes, flame tubes, furnace tong tips, balls for hot hardness testing, nozzle vanes and blades for jet engines, and many others.
WHAT forms are made?	Tubes, rods, bars, flats by extrusion process. More complex parts by machining from pressed slugs before sintering; extremely accurate parts by grinding to required tolerance after furnace sintering.
HOW can you use it?	This remarkable new metal, available in many "grades" to meet specific combinations of imposed conditions, can best be adapted to your high temperature problem by cooperative effort. Our engineers will be glad to discuss how you can get best results from Kentanium.

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where between the steam turbine and the internal combustion engine but beyond the scope of either in many ways. Faster shaft speeds, higher temperatures, unusual loads, new requirements for bearing seals and lubrication systems, particularly in aircraft applications, were experienced. While theoretical approaches could be made, it was necessary to correlate this work with actual performance data in enough instances to establish the relation.

Although the lighter weight associated with antifriction bearings and their lubrication systems were desired, their dependability was still to be established under the operating conditions expected. Also, design engineers were at that time unsure of their ability to balance compressor against turbine thrusts to a relatively small and controlled difference. Therefore, a sleeve bearing program was established during which one phase of study concerned the fatigue life of bearing metals. This came about because of still other doubts that existed in regard to design problems associated with turbine blading. Improvements needed in metallurgy and in the design for anchoring blading had been emphasized by the memorable loss of blading at shaft speeds as high as 35,000 rpm. As a result, the bearing program undertook to find bearing materials and designs that could operate for some reasonable length of time with the severe unbalance imposed by the loss of a turbine blade.

Test Summary: Several factors regarding bearing performance are of some significance to the design engineer and those concerned with the analysis of bearing failure.

All mechanical devices eventually wear out. A bearing is no exception. When it is designed adequately, installed accurately, lubricated properly, and serviced regularly, it must eventually be replaced either due to excessive wear or metal fatigue. In equipment having reciprocating parts or some unbalance, fatigue failure is the normal end of a good bearing.

While the lubricant or the bearing may be charged with the responsibility for bearing failure, me-

NATIONAL OIL SEAL LOGBOOK

Write our Redwood City office for reprints of this Logbook page

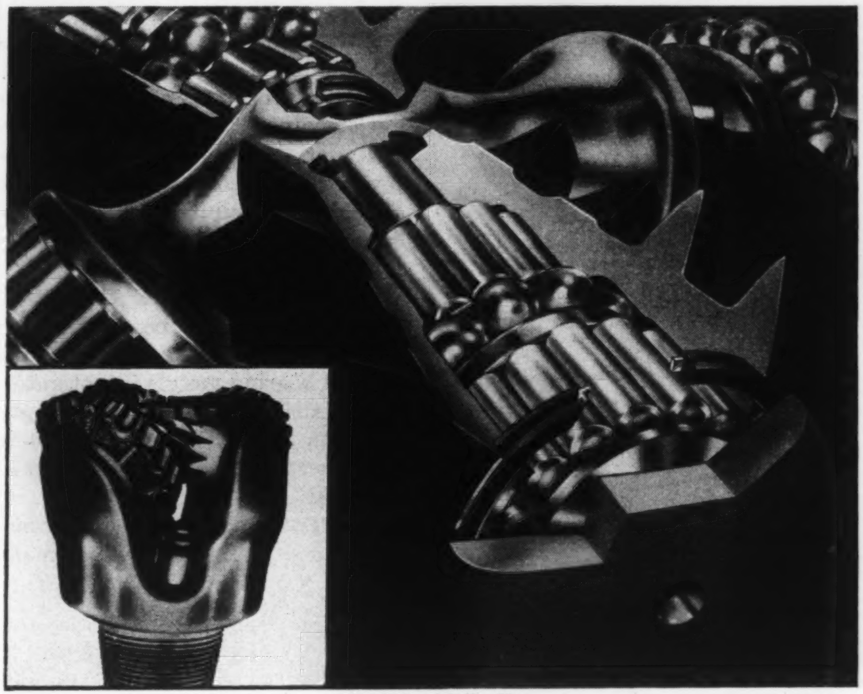

Fig. 1. Reed Roller Bit

National Syntech* Oil Seals lengthen life, improve performance of Reed roller bits

The conditions under which rotary rock bits operate are extremely severe. To lengthen bit life, improve performance and limit admission of abrasive materials from cutter bores, Reed Roller Bit Company utilizes National Oil Seals in their heavy-duty rock bits.

Three National seals—two standard design 360,000 series and one special design face seal—are installed in each bit. These seals are of springless design with precision-trimmed sealing lips of National Syntech synthetic rubber (Figure 2). The inherent "flex" action of the Syntech lip insures satisfactory sealing despite runout and the heavy impacts of rock drilling. The Reed Company reports that "Bits containing seals are in noticeably better condition than bits not containing seals—both being run under the same conditions and for the same length of time."

The National Oil Seals in this application illustrate but two of thousands of National designs. Perhaps your product can benefit by utilizing standard design National seals; perhaps special seals are required. In either case, our long experience with sealing problems is at your disposal.

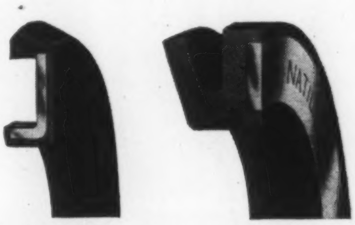

Fig. 2. (L) 360,000 series Syntech (R) 6543 Syntech

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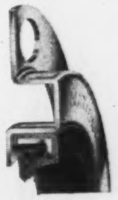
*T.M. Reg.

Sealing News & Tips

National 350,000 series with flange case



To simplify installation, many users specify National Oil Seals with flanges. Illustration shows a standard design National 350,000 series Syntech* Oil Seal with bolt-on flange. This spring-tensioned design with synthetic rubber sealing lip is often specified in applications involving high speeds and high temperatures.

National 50,000 series, modified

A standard design National seal, modified, with special flange. O.D. of flange press fits into housing. National 50,000 series leather seals such as this (with and without flange) are ideal for heavy-duty applications where seals may run semi-starved and external dirt or dust conditions are severe.

National O-Ring Catalog

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chanical and service factors are most often responsible. An understanding of them is necessary in eliminating factors causing unduly short bearing life.

Fatigue resistance is usually considered to be more important than all other properties of bearing metals combined. Particularly important service factors, such as the presence of corrosive conditions, should be recognized by the design engineer in selecting a bearing material.

Silver and aluminum alloy bearings were found to be most resistant to bearing fatigue among the several bearing metals investigated. Under some conditions, the fatigue life with these metals may be more than twenty times that of babbitt bearings.

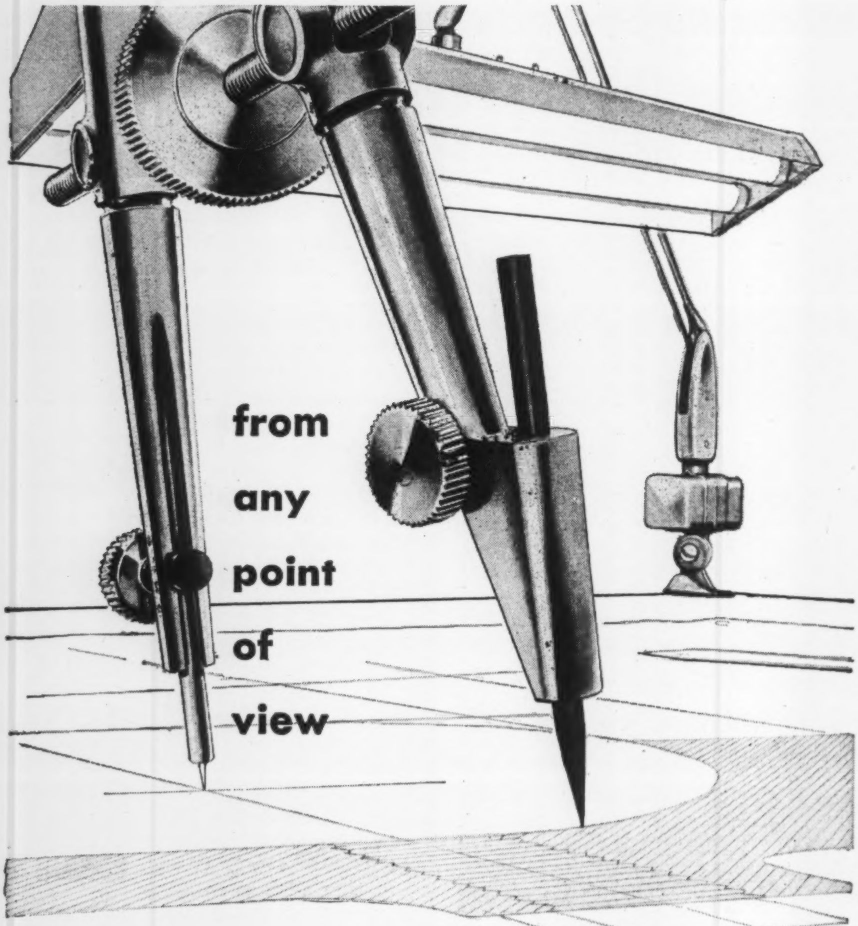
Weak properties of a bearing material may be improved in many ways. For example:

1. Conformability and antiscoring ability of silver bearings may be improved by the use of thin soft-metal overlays.
2. Adaptability of aluminum alloy bearings to conditions normally associated with plastic strain at high temperature may be improved by treatment of the metal, by bonding to steel backing, or by design methods.

Fatigue resistance of babbitt bearings may be greatly increased by reducing the thickness of the babbitt overlay placed on the steel backing. For example, a change from 0.015 to 0.003-inch increases fatigue life about three times.

A reduction in clearance reduces the tendency of a bearing to fail in fatigue. Fatigue life is approximately doubled when clearance is reduced from 0.007 to 0.003-inch. These improvements in bearing life with less clearance and less metal thickness are responsible for such a trend in modern high compression, high output engines.

Excessive temperatures increase the rate of oil oxidation and may lead to corrosion. High temperature also reduces the fatigue strength of bearing metal. One rule-of-thumb states that the life expectancy of a bearing is approximately halved by each 20 F increase in operating temperature



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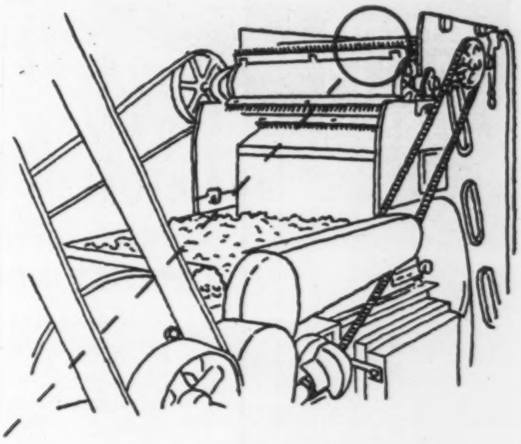

Du Pont nylon bristles end down time

Brushes manufactured by
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to clear impacted conveyor belt...improve fiber quality... cut costs

Fiber stock is usually shipped to textile mills in compressed bales. These bales must be opened and the fibers fluffed before yarn production can begin. In the case of cotton and some synthetics, part of this operation is done as the fibers are lifted from spiked conveyor belts. But in one mill, the rotating leather strips used to do this tended to compress the fibers again. The spikes became impacted. Stoppages were necessary to clear the belts. Production slowed. And new strips were required every six months.

Then, brushes with Du Pont nylon bristles were installed to remove the fibers. The tough, resilient bristles do not compress the fibers . . . produce a fluffier stock . . . keep the spikes completely clear of impacted fibers. Down time to clear the belts has been eliminated. Costs have been reduced . . . quality improved. Du Pont nylon's abrasion resistance means long, trouble-free service, too. These brushes have been in daily use for over two years, yet show no apparent wear.

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above 160 F. A typical tin-base babbitt has a Brinell hardness of 24 at 70 F which is reduced to 8 at 300 F. The material becomes almost plastic at 400 F and is completely melted at 465 F. Certainly the oil reservoir temperature should never exceed 300 F. Unfortunately the highest temperatures are often reached at times when excessive speeds and loads impose the greatest stress on bearings.

Location of grooving with respect to load areas is well understood. Selection of the proper type of grooving will depend upon the requirements of the application. Circumferential grooving probably offers the best distribution of lubricant over the entire bearing and provides an aid for dissipating heat forced upon the bearing from other sections of an engine.

It is sometimes suggested that fatigued bearings should be replaced:

1. When 10 to 20 per cent of the bearing area is affected by fatigue cracking.
2. When a fatigue pitted area threatens to disrupt the oil film by providing an escape for the oil from the loaded area.

While tests have demonstrated that fatigue progresses in approximately equal steps until these limits are reached, it is often economical to replace relatively inexpensive bearing inserts showing less damage whenever a costly disassembly of an engine has been necessary for other reasons.

From a paper entitled "Bearing Failure — With Emphasis on Fatigue" presented at the meeting of the ASME South Texas Section in Austin, Texas, December 1952.

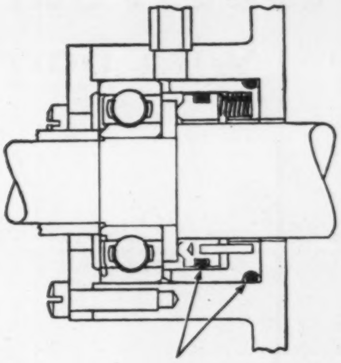
Design Factors in Production Balancing

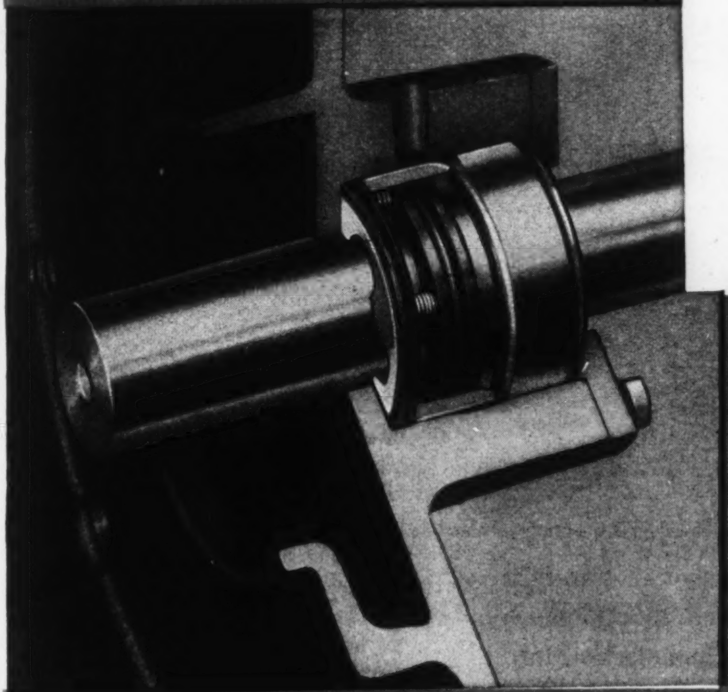
By George C. Lawrie
Chief Engineer
Tinius Olsen Testing Machine Co.
Willow Grove, Pa.

BASICALLY, the balancing operation, when properly done, removes undesirable vibration. While this is the most important end result, there are a number of

A PAIR OF PRECISION "O" RINGS

makes possible this oil seal's simple design and maintenance-free performance!





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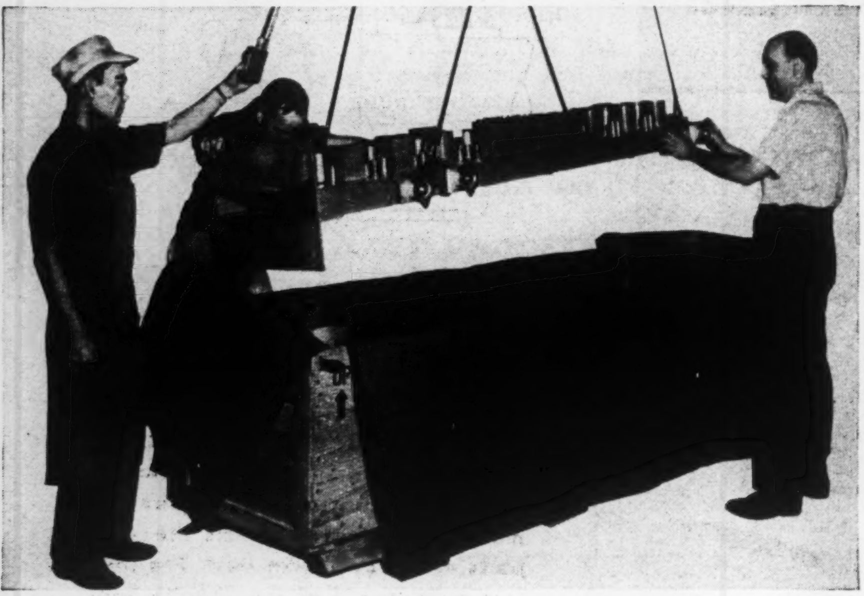

Photograph courtesy of PHILCO CORPORATION, Government and Industrial Division

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by-product benefits which are perhaps not so well known nor as obvious. First, the need for balancing increases as the square of the speeds, since the shaking forces due to unbalance increase as the square of the speed. The high speeds in common use today would, in many cases, be utterly impossible without adequate balancing. By reducing or eliminating vibration caused by unbalance in a rotating body, smoothness and quietness of operation are greatly improved. Although these qualities are self-evident, not so apparent are benefits resulting from longer bearing life, decreased oil consumption in machines where it is an important factor, and improved overall efficiency.

Unbalance Causes: It is important to understand what causes unbalance, since in many cases the causes can be minimized by proper design, and by taking certain precautions in some of the manufacturing operations. The causes of unbalance are many, depending upon the type of machine under consideration, but basically it is due to lack of symmetry of mass distribution about the axis of rotation of the body. In other words, the mass axis and the geometric axis do not coincide. Sometimes this results from errors in design where inadequate provision has been made for inherent unbalanced forces.

If the rotating body is made up in whole or in part of a casting or forging, there is likely to be considerable unbalance present in the finished part, since the unmachined surfaces cannot be held concentric with the axis within very close dimensions. In castings, in particular, the material may lack uniform density, with resulting unbalanced forces when the part is rotated.

Inaccuracy in machining, allowing eccentricity of the bearing surfaces, is another sure way to end with an unbalanced part. The same is true of parts making up any rotating assembly. Fits of mating parts must be held closely, otherwise individual parts may be assembled in an eccentric position with relation to the bearing sur-

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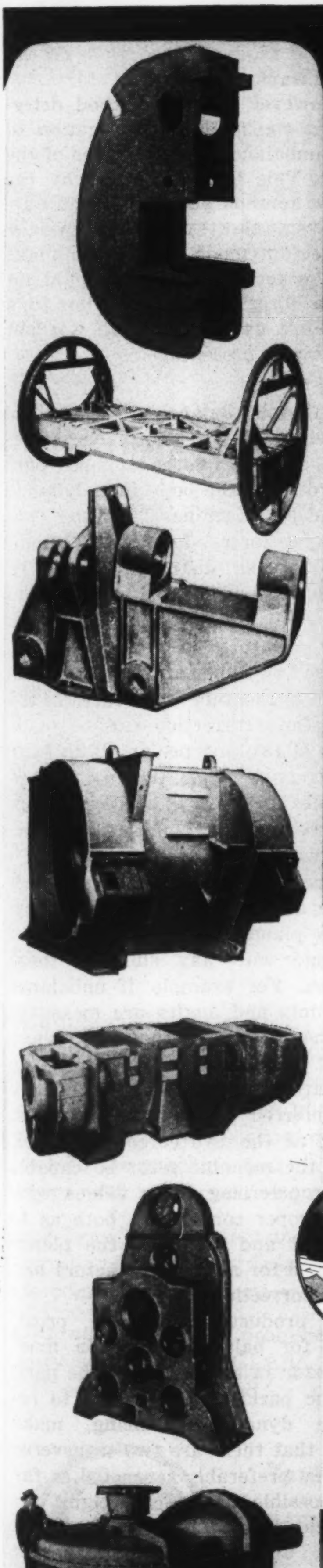
faces, and thus possibly introduce a heavy unbalance. This holds true even though the individual parts may be in perfect balance about their own axes.

Production Considerations: In many assemblies, it is possible to have heavy unbalance present, even though the individual parts are perfectly balanced and the fits held to extremely close tolerances. The fact that mating faces of the assembled parts may not be perfectly square with the shaft axis may cause the shaft to be sprung out of line when they are clamped or bolted together in the assembly. Typical examples of such a condition are some types of centrifugal pump impellers where the individual impellers are separated by tubular spacers and the whole is clamped on to the pump shaft. Very slight inaccuracies in the squareness of either the impeller hub faces or of the ends of the spacers, or both, can create enough deflection in the shaft to cause a considerable unbalance.

In the case of a motor armature on which the laminations have been stacked out of square with the axis of the shaft, a surprisingly large unbalance may result, but for an entirely different reason than in the case of the pump impeller. The armature shaft may be perfectly straight but the centers of gravity of the two dimetrically opposite sides of the armature laminations have been displaced along the length of the armature, due to the cocking of the laminations, thus introducing a dynamic unbalance, even though the rotor is still in perfect static balance.

Static Balancing: This is the term usually applied to single-plane correction for balance, and should be confined to parts which are relatively short in relation to their diameter. Static unbalance can be determined by the use of level ways or rollers, or by rotating the part in a static balancing machine which utilizes the centrifugal force of the unbalance to permit measurement of the amount and angular location of the unbalance. The latter method achieves a much higher degree of accuracy than is possible with



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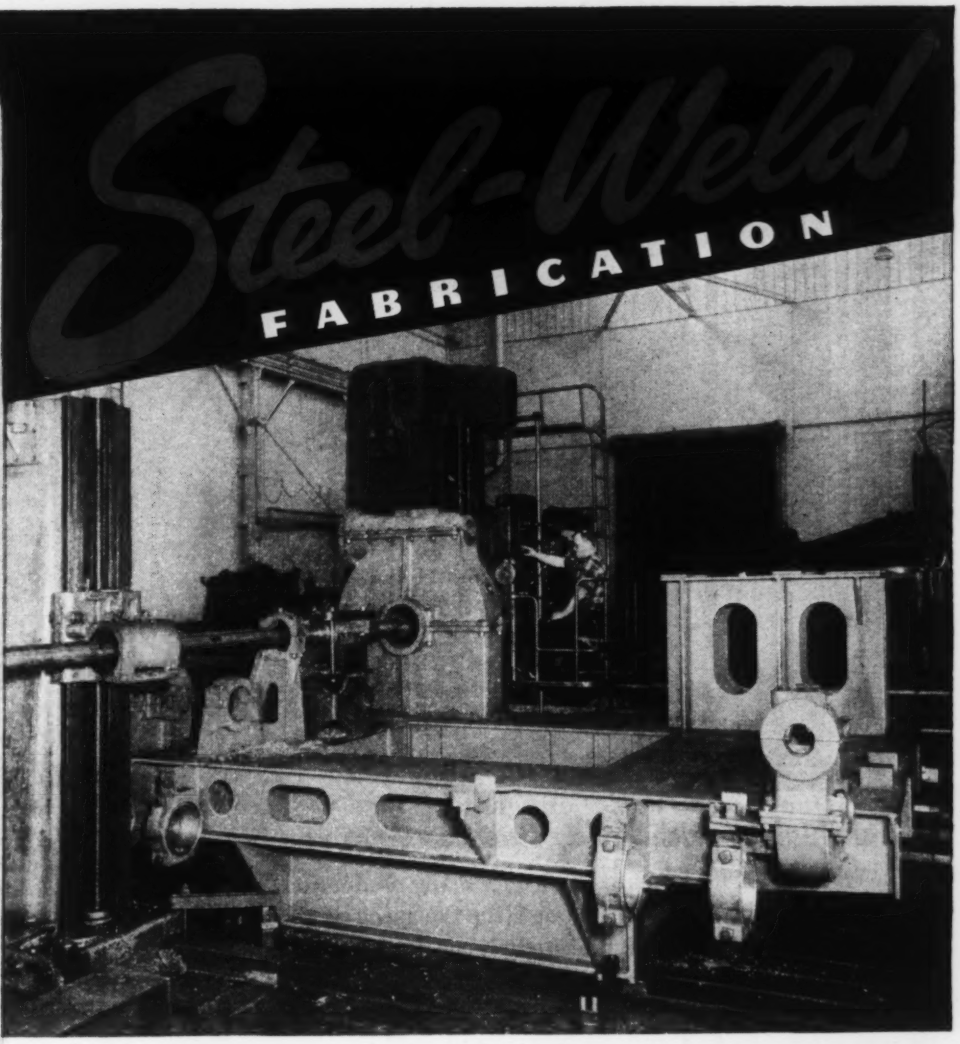

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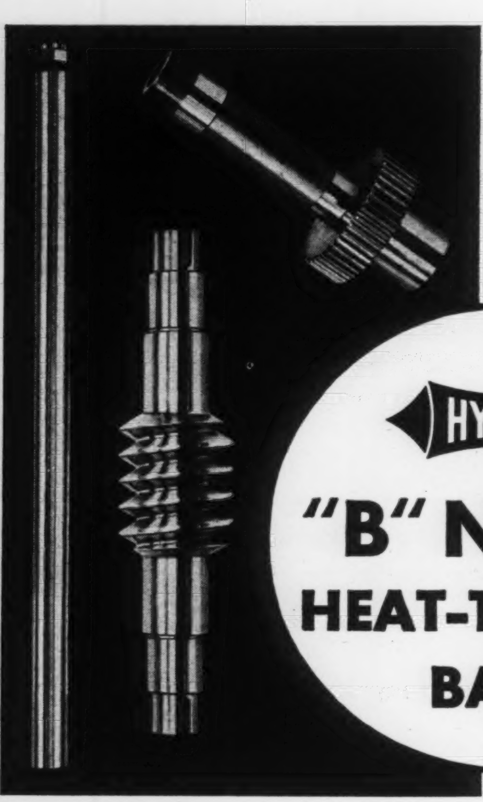

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level ways.

However, neither method determines the longitudinal location of the unbalance along the axis of the part. This is the reason why the static method should be used only for very short parts, otherwise a correction made out of the plane of the actual unbalance would set up a force couple, resulting in a dynamic unbalance which was not originally present.

Dynamic Balancing: This term usually refers to two-plane correction, and can be accomplished only by rotating the body in a dynamic balancing machine. Thus the centrifugal forces due to the unbalanced mass distribution can be measured and located angularly in any two transverse planes which may be selected for correction. These two forces are the resultants of all elementary unbalances in the body and correction can be made only at two or more points to form a corrective couple. Where a dynamic unbalance exists, correction cannot be made by adding or removing weight in one plane only.

The amount and angle of unbalance, as measured in any two transverse planes through the body, will change with any shift in these planes. For example, if unbalance amounts and angles are measured at the bearings of the work, where most balancing machines pick up vibration, these values will change if referred to any other planes, such as the two corection planes, and the machine must be capable of transferring these values with the proper corrections, both as to amount and angle, to the planes selected for making the actual balance corrections.

In production balancing, provision for balance correction must be made in the design of the part. If the part is long enough to require dynamic balancing, make sure that there are two transverse planes, preferably separated as far as possible, in which weight can be added or removed. This is too often overlooked in the design stage, with resultant higher cost and inconvenience in the balancing operation.

The importance of dynamic balancing, especially in view of the

CLARK TYPE "CY" STARTERS

efficiently control STAMETS Heavy-Duty Machines and speed shell production!

In several plants, Wm. K. Stamets No. 2R Shell Cut-Off machines, and Shell Lathes are producing 105 MM and 155 MM shells at a high rate.

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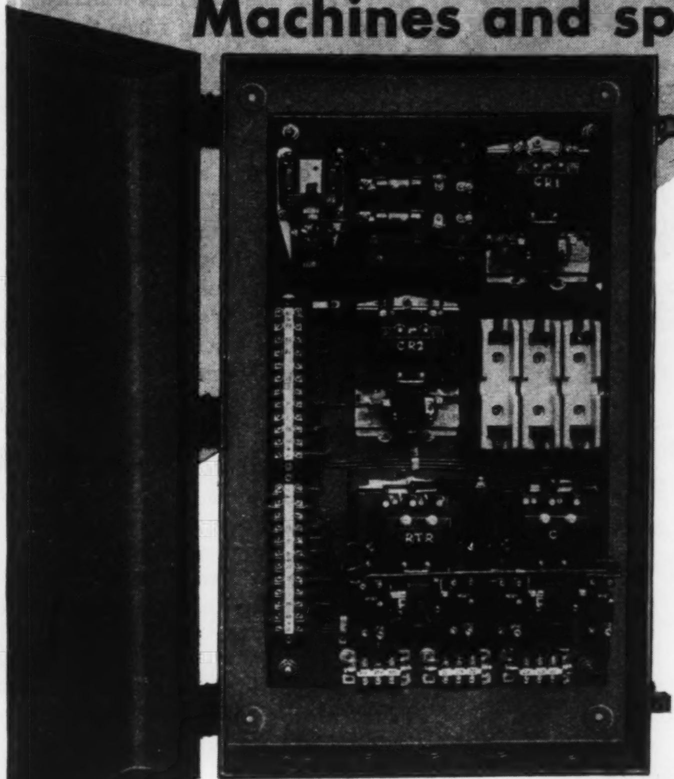
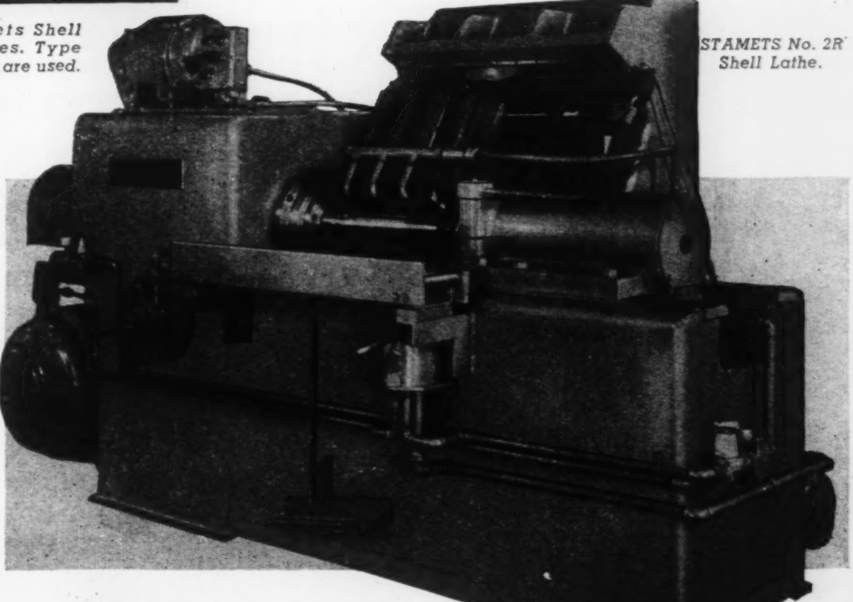


CLARK Control for Stamets Shell Roughing or Finishing Lathes. Type "CY" Contactors and Starters are used.



STAMETS No. 2R Shell Lathe.

Desirable cushioned stopping of the roughing spindle motor is accomplished by using current limiting resistance in the reverse plugging circuit. Smooth fast stopping, with no shock to the machine and no interference with production rate results.

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present day tendency toward higher and higher speeds, is emphasized in *Fig.* 1. This shows a curve of centrifugal force exerted by an unbalance of only one ounce-inch at various speeds. This centrifugal force is the shaking force that can be felt in the machine bearings or housing. It is interesting to note that this comparatively small unbalance of one ounce-inch, exerts a force of only slightly over one ounce at a speed of 200 rpm, but in a rotor operating at 5000 rpm, this same small unbalance will exert a force of nearly 45 pounds. Doubling the operating speed to 10,000 rpm—not an uncommon speed today—results in a shaking force four times greater, or nearly 180 pounds.

How to Balance: Probably the quickest and most accurate method of making balance corrections, especially in production balancing, is by drilling to remove weight. The weight removed can be accurately controlled by regulating the depth or number of drilled holes. This can be done manually or, in some of the more modern machines, drilling can be done entirely automatically, the depth being controlled by the signal from the balancing machine. Metal can also be removed by grinding, but since this method relies entirely upon the judgment of the operator as to how much weight is removed, it is not much used in production balancing.

If the construction of the rotor is such that it is not practical to remove weight by drilling or otherwise, then balance correction must be effected by adding weight in

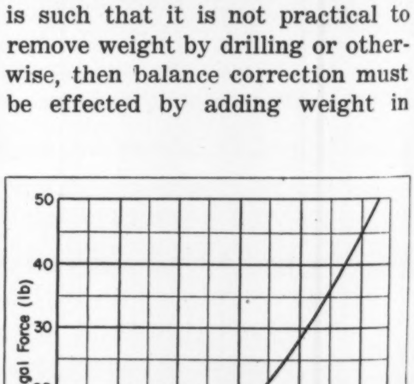
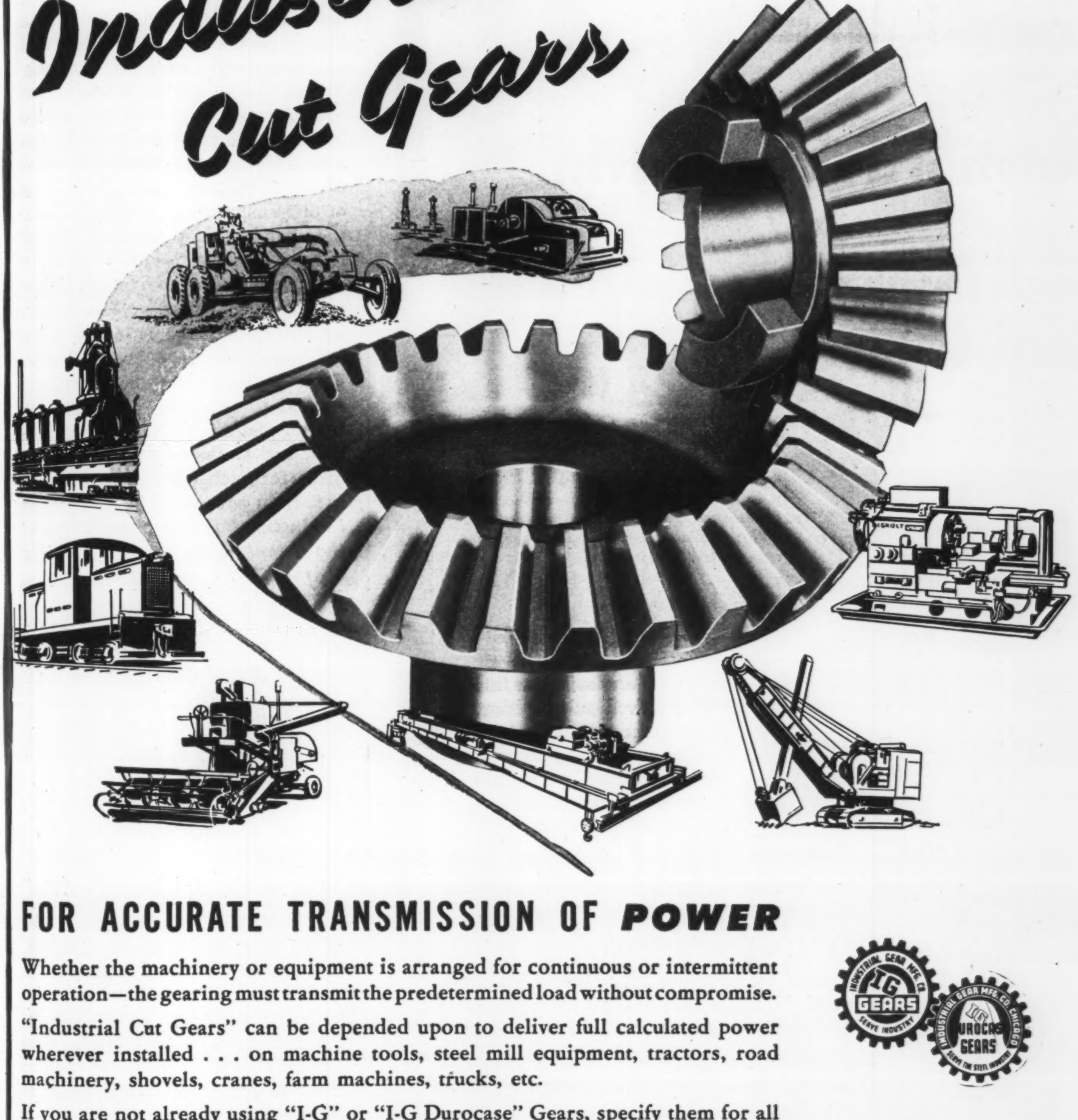


Fig. 1—Centrifugal force exerted by one ounce-inch of unbalance

Industrial Cut Gears



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some manner. Here again, in order to correct on a production basis, provision should be made in the design of the part, for quick and accurate weight addition. Probably the most convenient means is the use of slugs graded in weight to be spot welded to the part or otherwise attached. In some types of motor armatures, preformed slugs of different lengths are driven into the armature slots at each end of the laminations, corresponding to the two planes of correction. Other parts, such as separator bowls, may be corrected by flowing on a calibrated length of wire solder. Each part should be carefully studied to determine the most efficient method of balance correction, and the necessary provisions made for such correction.

From a paper entitled "Precision Production Balancing" presented at the Twenty-First Annual Meeting of the ASTE in Detroit, Mich., March 1953.

Applying the Wound-Rotor Motor

By R. F. Woll
Design Engineer
A-C Motor Engineering Dept.
Westinghouse Electric Corp.
Buffalo, N. Y.

SELECTION of a motor for a given job involves, essentially, four choices. If the machine to be driven must run at constant speed, the choice almost inevitably is a synchronous motor. This motor requires a source of direct current for excitation, a suitable control and is relatively expensive. At the other extreme, if a wide range of speed control is necessary, easily and efficiently, and if dc power is available, some form of dc motor is the probable choice. However, by far the majority of jobs in industry can be performed by the simple squirrel-cage induction motor. Its speed falls off only slightly with increasing loads. It has the great merit of being the simplest of all motors, requires the least control, and is lowest in cost. But its speed (on a constant-frequency, constant-voltage power supply) is dictated solely by the load—it is subject to

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MODEL 205 FULL HYDRAULIC LADDER

repairmen go airborne . . . with HYDRECO Oil Power

Full Hydraulic Ladder made by J. H. Holan Corporation, Cleveland, manufacturer of automotive equipment for public utilities, uses HYDRECO pump, valves and cylinder. Ladder has unlimited swing, infinite number of elevations, adjustable platform.

HYDRECO Oil Power puts trouble-shooters in the air with ease and safety on this new full hydraulic ladder. The repairman can spot the ladder accurately, move it in any direction by a simple three-lever control unit.

The ladder is equipped with HYDRECO pump, valves and cylinder for top speed and efficiency, easy operation, trouble-free performance, and absolute safety.

HYDRECO Oil Power features include:

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no control.

There are, however, many applications for motors that do require operation over a limited range of different speeds. For these, particularly where direct current is not available, the wound-rotor induction motor is a good choice. Its control is fairly simple, and it has no commutator, with its attendant maintenance problem.

Basic Types: A wide range of speed-torque characteristics can be obtained from a single wound-rotor induction motor by varying the amount of external resistance in the rotor circuit. Wound-rotor motors are customarily grouped in three categories, depending upon the application for which they are intended and the type of rotor-resistance controller used, although the distinction among the basic motor designs is negligible. General-purpose motors are usually continuous rated and matched with a secondary controller. Operation below 50-per cent speed is not recommended. Crane and hoist motors are intermittent rated and also matched with a secondary controller. These may have slightly more breakdown torque than the general-purpose motor. Special-purpose motors are intended for applications of a special nature where the service and/or required controller is beyond the scope of the two standard categories.

Range of Application: Although there are numerous and varied applications for wound-rotor motors, the most common are those requiring speed variations. These can be subdivided into two classifications—variable-torque and constant-torque applications—which are quite readily defined.

A good example of a variable-torque application is a fan drive. The wound-rotor motor should be applied to fan drives in those cases where a varying volume of air is to be delivered. This is achieved by operating the motor at selected speeds between full speed and approximately 75-per cent speed. However, where sufficiently accurate control of air delivery can be obtained by alternately operating

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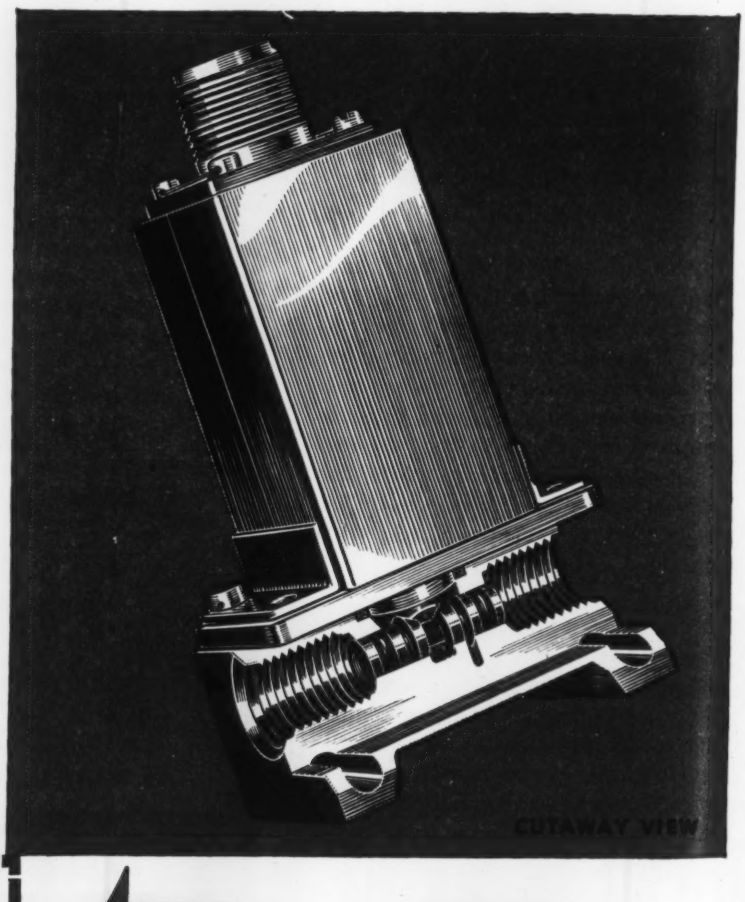

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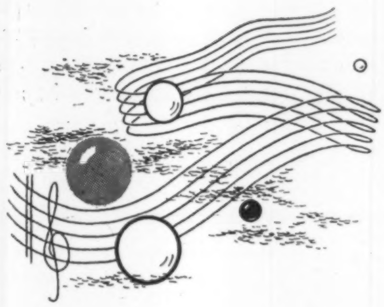

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the fan at one of two, three, or four definite speeds, a multispeed squirrel-cage motor should be used. This is accomplished by reconnecting the stator winding or by the use of different stator windings to give different numbers of poles. As the number of poles increase the maximum torque available drops off sharply. This is acceptable with fan drive, however, because the torque required to drive a fan decreases rapidly as fan speed is reduced.

Due to winding-space requirements (limiting the number of separate stator windings to two), only certain pole combinations are available in a given motor. The available operating speeds for the multispeed squirrel-cage motor are in relatively large steps, whereas with the wound-rotor motor a series of closely spaced operating speeds is available, enabling closer control of air volume.

Speed Reduction Limited

It is advisable to stress a limitation in the use of wound-rotor motors for applications involving speed reduction. Basically, the speed at which any induction motor runs depends somewhat upon the amount of load it is called upon to deliver. However, changes in speed for a considerable change in load are relatively small, which is the reason the induction motor is thought of as an inherently constant-speed machine. In the case of a wound-rotor unit having large external secondary resistance, this characteristic can lead to an operating speed quite different than intended. For very light loads, no appreciable speed reduction can be effected by adding external resistance in the secondary circuit.

A good example of a variable-speed, constant-torque application is a conveyor that must be driven at different speeds, depending upon the desired rate of loading or unloading. The variable-speed characteristics of the wound-rotor motor are well suited to this application. However, the slowest operating speed of the motor should not be less than approximately half the synchronous (no-load) speed, for

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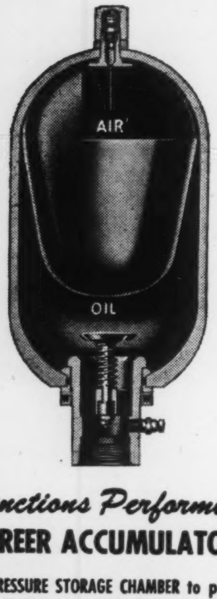

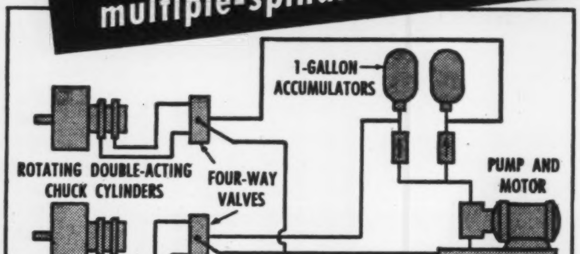

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two reasons: first, although both rotor and stator losses of a wound-rotor motor at a given torque output are essentially the same at any reduced speed as they are at full speed, the lessened ventilation at the slower speeds causes overheating if such operation is prolonged; second, a slight change in load produces a marked change in speed, with consequent danger of unstable operation.

Similar to the fan application, if the speed requirements of the conveyor can be satisfied by up to four definite speeds, then a multispeed squirrel-cage motor should be used. Pole-combination limitations are identical to those of the variable-torque multispeed motor, as is the relative spacing of the available operating speeds compared to the wound-rotor motor.

Another common application for wound-rotor motors is that requiring smooth acceleration combined with high torque. This application is exemplified by the large overhead crane. Both the hoisting and trolley movements are properly powered by wound-rotor motors, taking advantage of the low starting torque with maximum external rotor resistance; the external rotor resistance is then changed to successively lower amounts for increasing the speed and torque output of the motor, until the desired rate of hoisting or trolley motion is attained. Wound-rotor motors in hoist service are usually employed only in the larger cab-operated cranes that lift heavy loads, where a severe jolt at starting could be hazardous to personnel or equipment, and where a choice of hoisting speeds is desirable or necessary.

For smaller cranes operated from the floor and having only the hoisting movement powered, and where hoisting at only full speed is acceptable, high-slip squirrel-cage motors are almost universally used, since any jolting at start is of less consequence with the lighter loads. Also, the severity of the starting jolt can be minimized by "inching" the small motor, whereas this causes intolerable wear on large motors.

Special Applications: For certain applications the characteristics of

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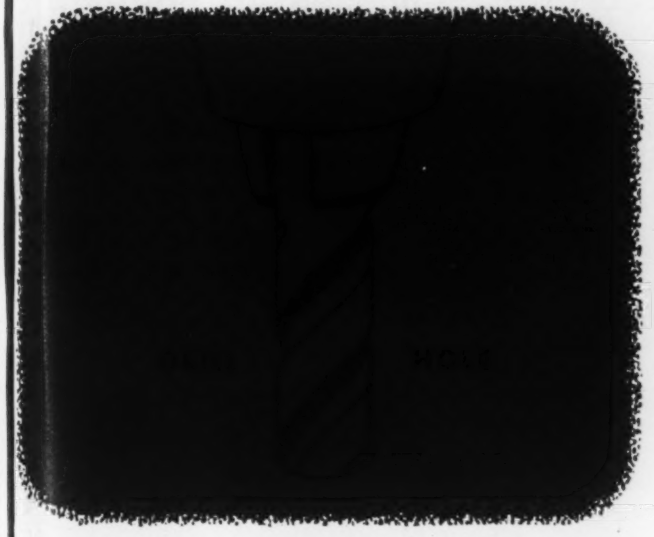

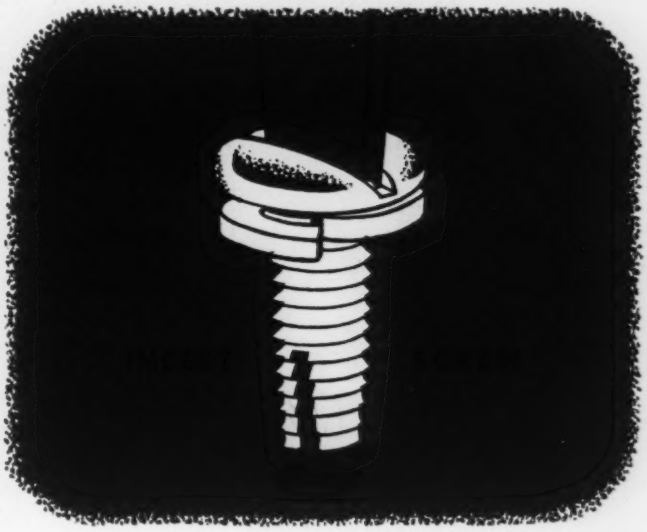

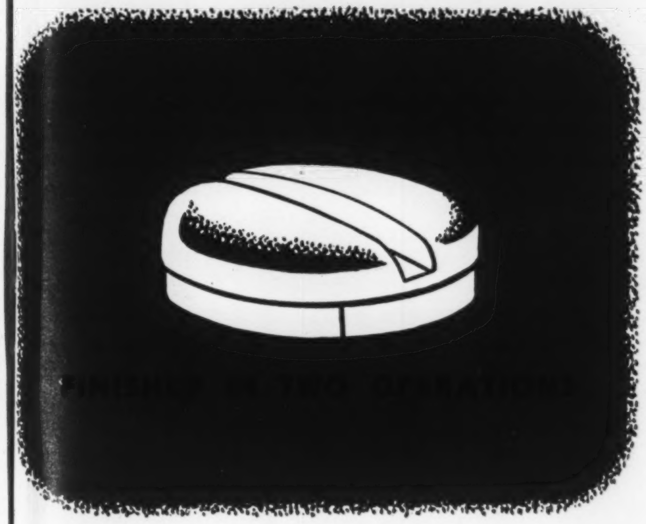

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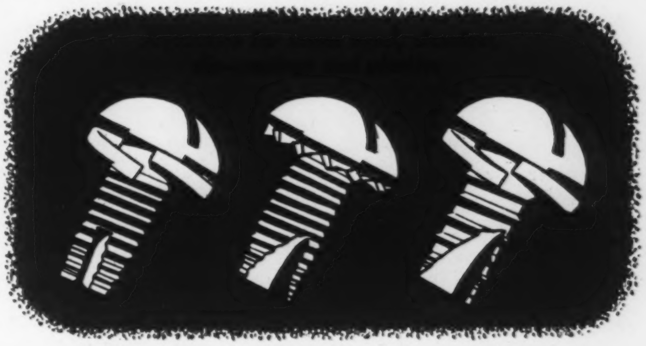

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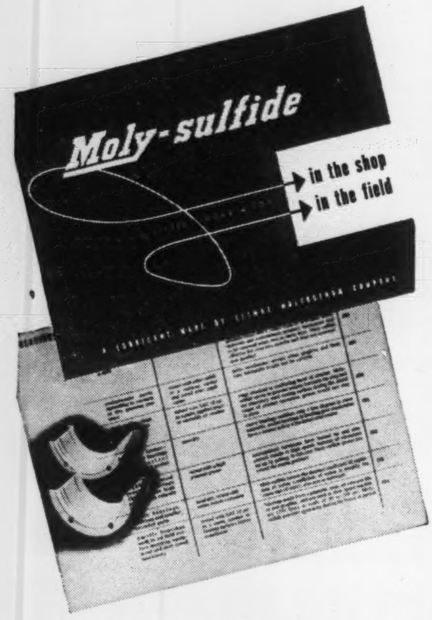

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the wound-rotor induction motor make it the preferred drive. For example, take a cable-reeling machine. Cable is wound on a reel driven by a suitable constant-speed motor. Consequently the linear speed at which the cable moves increases as the reel fills up. The cable must be kept under slight tension as it is wound to prevent crossing or tangling on the reel. Further, while the amount of tension need not be perfectly constant, it should remain at a fairly uniform value to prevent too much stretch or too much slack. To accomplish this, the cable is controlled from an auxiliary drum connected to the shaft of a wound-rotor motor having very high external rotor resistance. The speed at which the wound-rotor motor runs depends on the linear speed of the cable, and even if this were to vary as much as two to one, the tension applied to the cable by the wound-rotor motor would be satisfactorily constant.

In applications requiring development of torque at zero speed for any appreciable length of time, the wound-rotor motor can be used, although locked operation is not too desirable for any motor because of the large heat losses present under locked conditions. The wound-rotor motor is superior to the squirrel-cage for these applications for two reasons: first, the major portion of the rotor loss is dissipated in the external resistors without producing heat in the motor proper; second, extremely high rotor resistance gives minimum stator loss for a given locked torque.

Where capacity of the power supply is limited, the wound-rotor motor can be used for applications normally assigned to squirrel-cage motors because it has the lowest starting current for a given starting torque of any type of induction motor.

Since their characteristics are somewhat similar, the choice between squirrel-cage and wound-rotor motors should be made carefully. Each has its own field.

From an article of the same title appearing in the Westinghouse Engineer for March, 1953.

DESIGN IDEA CUTS PRODUCTION COST 50%

SIMPLE replacement of heavy cast covers with welded steel units effects an 80% reduction in weight on elevator machine covers at The Shepard Elevator Company, Cincinnati, Ohio. At the same time, manufacturing cost is 50% less. These direct savings result from less material and elimination of machining required on former castings.

Weight reduction is particularly important on this equipment since elevator machines are usually mounted on upper floors of multi-story buildings. Easier handling within the manufacturer's own plant as well as lower shipping charges further add to lowering total costs.

In manufacture, it was originally necessary to mill the bottom edge to form an oil-tight seal. This entire operation is now eliminated. The complete unit is manufactured within the shop and without dependence on outside sources for castings.

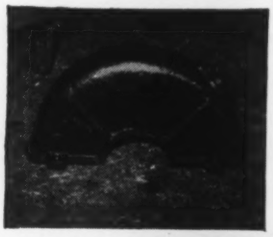

Fig. 1. Original construction of gear case cover weighed 66 pounds and required milling of bottom edge for oil-tight seal with gear case.

Fig. 2. Steel designed gear case cover now used weighs only 10 pounds and costs half as much to produce. Fabricated entirely within manufacturer's own shop by welding.

Fig. 3. Assembly of cover on gear case. Cover is 16 gauge sheet metal welded to plain angles forming oil-tight seal with main gear case.

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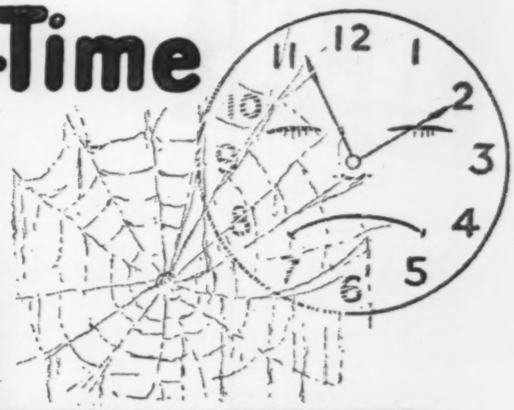

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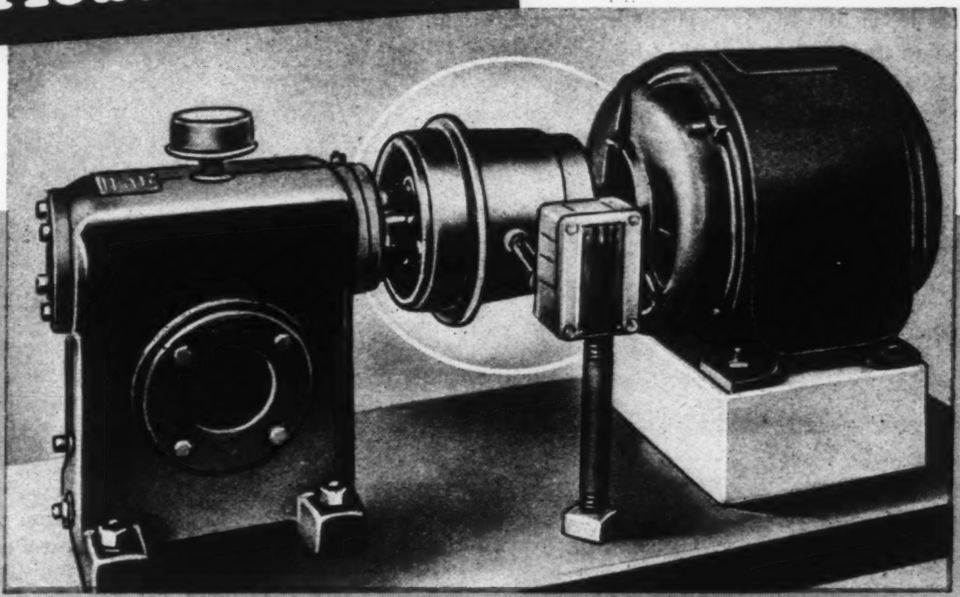

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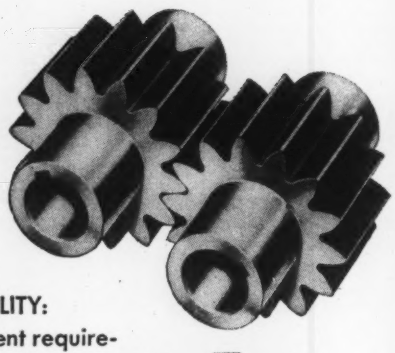

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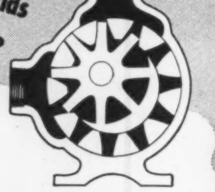

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FOR THREE-JOINT STRINGS

FOR CRAMPED SPACE

FOR EASY INSTALLATION

Why TAP-LOK* INSERTS have the edge on other threaded bushings

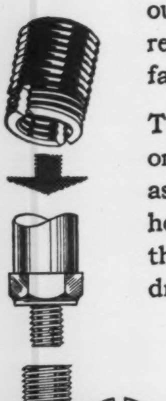
This CUTTING EDGE taps the thread

The cutting edges on the slotted segments of Tap-Lok Inserts make all the difference in the world. They eliminate one time-consuming task — the separate tapping operation. That represents a substantial saving in assembly.

The Tap-Lok Insert is a bushing that is threaded externally to tap its way into a drilled or cored hole equal in size to a tap drill hole that will accommodate the external thread. The Insert is also threaded internally to receive the male threaded member.

The Tap-Lok Insert withstands vibration without loosening and has maximum torque-and-pull resistance. It is not subject to the time-wasting failures of cast and molded inserts.

Tap-Lok Inserts are used in large volume as original equipment on regular production line assembly. In addition, they save many man-hours in salvage work for repairing stripped threads. They are easily inserted with a simple driving tool as shown in the drawings to the left.



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Also manufacturers of Groov-Pins for positive locking press fit

GROOV-PIN CORPORATION

1129 Hendricks Causeway
Ridgefield, New Jersey

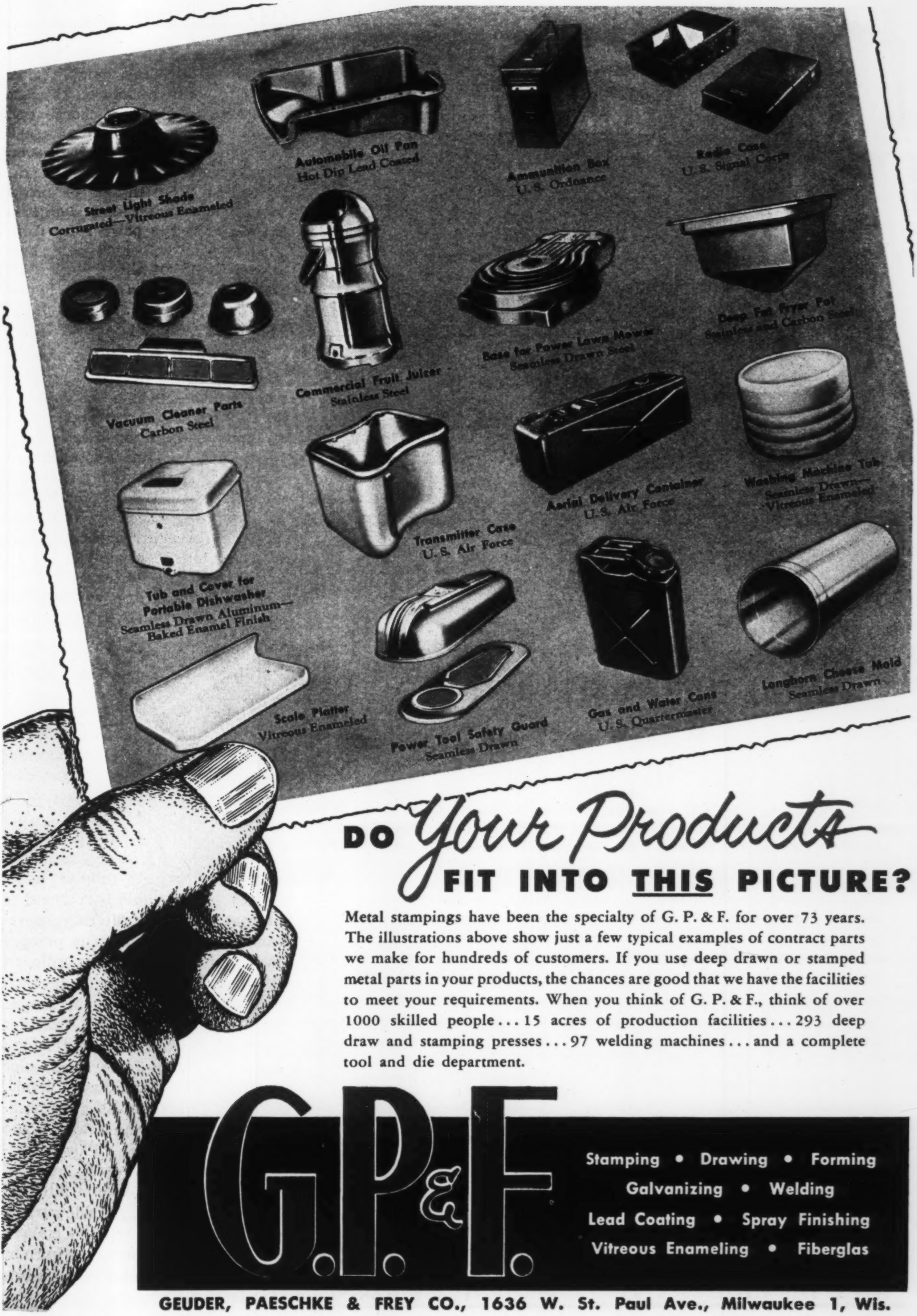
U. S. Patent 2,455,885
*Reg. U. S. Pat. Off.

signed especially to handle warm stock, but extremely rigid bed makes possible cold forming up to capacity of machine. Different tools may be set up on top of one another so that successive operations may be done in the same heat. Upsetting, punching and shearing can also be accomplished. Driven by adjustable friction clutch drive which will slip before any damage occurs to machine in the event of an overload. Brake and clutch are interconnected. Capacity, 100 tons; length of stroke, 10 in.; strokes per minute, 15; face of crosshead, 36 by 10 in.; daylight with crosshead forward, 10 in.; develops 10 hp. *British Industries Corp., International Machinery Div., New York, N. Y.*

Air Impact Press: Model "52," for high-speed marking, assembling, branding, staking, crimping, riveting, light stamping. Operates at speeds up to 10,000 strokes per hour. Develops pressure up to 8 tons from 100-lb air line; is adjustable for light to heavy marking. Can also be regulated to give proper ram action required for branding or color leaf marking. Can be actuated by hand, foot or electrical controls. Requires no special jigs or fixtures for average work. Has automatic controls which makes possible high production. *Cadillac Stamp Co., Detroit, Mich.*

Plant Equipment

Endless Belt Filter: "Vacumatic" provides automatic, continuous filtration of water-soluble coolants for individual grinders, hones and other machine tools. Use of vacuum provides faster filtering than gravity method. Two models available, one for flow rates of 20 gpm and another for 40 gpm. Both attach to machine tools in space usually required by sump tanks. In operation, used oil flows from machine tool into filter cabinet where it is spread evenly across an endless, moving filter belt. Motor-driven belt moves continuously forward over vacuum chamber, and coolant filters through belt into chamber, from which it drains into a clean coolant sump. It is then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Corrugated—Vitreous Enameled
Automobile Oil Pan
Hot Dip Lead Coated
Ammunition Box
U. S. Ordnance
Radio Case
U. S. Signal Corps
Vacuum Cleaner Parts
Carbon Steel
Commercial Fruit Juicer
Stainless Steel
Base for Power Lawn Mower
Seamless Drawn Steel
Deep Fat Fryer Pot
Stainless and Carbon Steel
Tub and Cover for Portable Dishwasher
Seamless Drawn Aluminum—Baked Enamel Finish
Transmitter Case
U. S. Air Force
Aerial Delivery Container
U. S. Air Force
Washing Machine Tub
Seamless Drawn—Vitreous Enameled
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Completes Forming of
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To Achieve Economy . . . Speed Delivery

The defense-related part here illustrated was originally made from solid bar stock requiring excessive machining hours to rough out. High material cost of "X-4130" steel was also a factor. Forging was impractical because of excessive die costs and the limited number of pieces required.

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recirculated to the machine by the built-in clean coolant pump. Solid particles which remain on the belt are carried toward discharge end of unit where a vibrator loosens such residue and causes it to drop into a removable tote box. Coolant is held substantially at or below room temperature, and sludge is dewatered and in powder-dry form when discharged into tote box. Also, passage of air through coolant reduces bacteria count. *Industrial Filtration Div., U. S. Hoffman Machinery Corp., Syracuse, N. Y.*

Floor Marking Machine: Florline machine has a third retractable wheel which acts as a line guide 18 in. forward of the carriage. Arm on guide wheel automatically folds back when machine approaches a curb or wall, permitting marking up to barrier. Raising the handle lifts marking brush so that machine can be rolled on three wheels to other areas. Operates around and close to machinery and stock. Florline-X makes lines within 1/8-in. of partitions. *H. C. Sweet Co., Detroit, Mich.*

Filters: Redesigned to reduce amount of floor space required. Control valves are grouped in front of filter at a height accessible to workers. Filtration is accomplished in three cycles. In precoating cycle, filter-aid is mixed with clear liquid in precoat tank, and mixture is pumped into filter chamber where filter-aid deposits on the outside of porous tubular membranes. Clear liquid is returned to precoat tank. In filtering operation, unfiltered solution is pumped into filter chamber where sediment is deposited on a layer of filter-aid and clear filtrate is discharged from outlet. Suspended particles down to 0.1-micron are removed without affecting taste, smell, color or chemical composition of liquid. Cleaning is accomplished by backwashing or reversing flow of liquid through membranes. Flow of water under pressure from inside of membrane knocks cake of filter-aid and sediment from outside surface of membrane. To simplify maintenance, motor and pump are in front of precoat tank and filter chamber. Available with water capacity of

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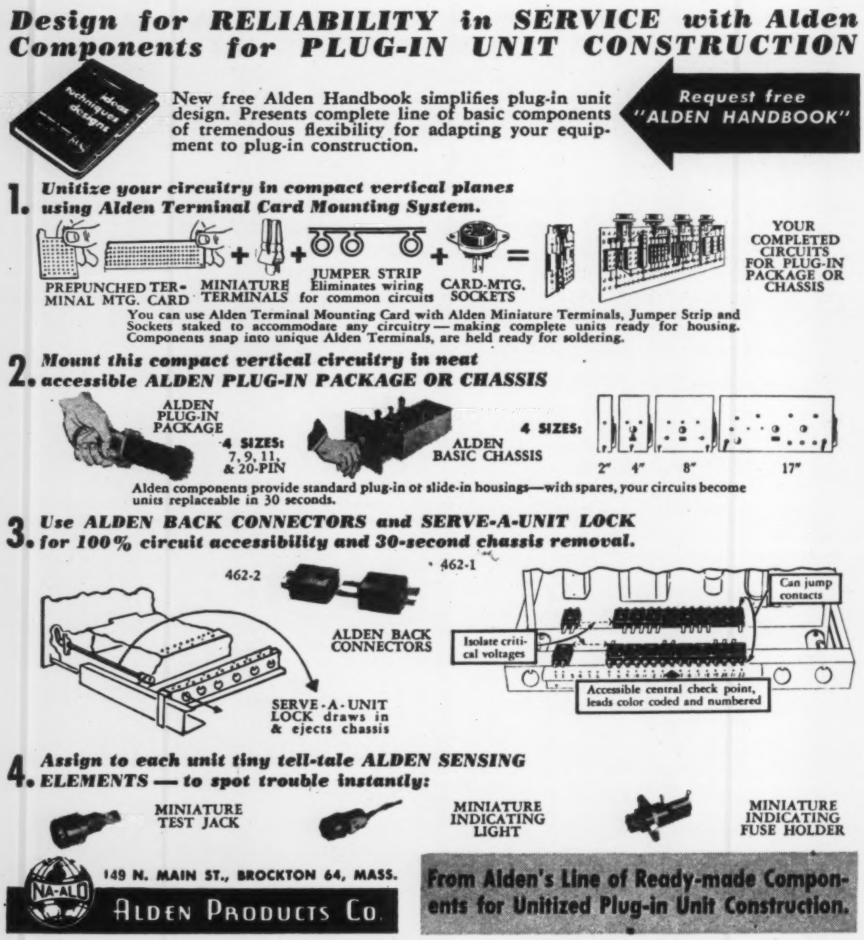

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YOUR COMPLETED CIRCUITS FOR PLUG-IN PACKAGE OR CHASSIS

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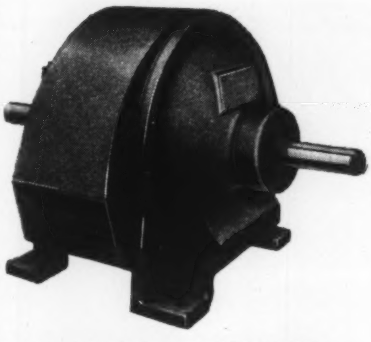
Portable Tools

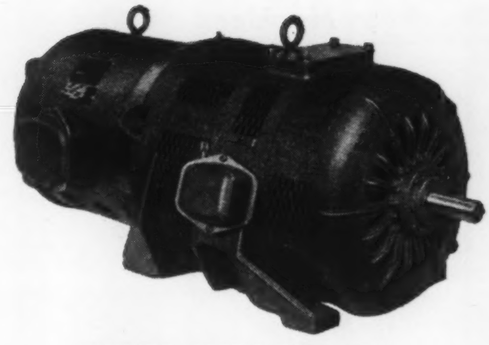
Electric Arc Welder: Lightweight, hand portable. Welds, brazes, solders, cuts or preheats, using either the metallic arc or carbon arc process. Heat range is 15 to 200 amp or more. Uses electrodes from 3/64 to 5/32-in. Has 50 per cent duty cycle. Size: 10½ in. long, 7 in. wide, 6¼ in. high. *Royal Equipment Corp., Burbank, Calif.*

Angle Iron Cutter: Cuts with straight, clean shear and causes no deformation of angle iron end. Capacity, 3 by 3 by ¼-in. or 2½ by 2½ by 5/16-in. Need not be bolted down or otherwise mounted for operation. Portable models have hydraulic hand pump; electric-hydraulic pumps available for production cutting applications. Cutters also available for cutting special shapes such as channel or H-beam. *Manco Mfg. Co., Bradley, Ill.*

Lift Attachment: For portable die handler which takes heavy dies apart. Motorized attachment drives upper platen of die handler at the rate of 16.3 in. per minute. Fine adjustments are made by means of hand crank. Safety feature makes necessary disengagement of hand crank before connecting motorized lift; likewise lift must be de-energizing before hand crank is reconnected. Operates on 110 volts ac. Lift can be furnished in accordance with JIC regulations—controls incorporate approved contactor box on rear of machine. Motor operates on 440 volts, three-phase and controls operate on 110 volts. *Hansford Mfg. Corp., Rochester, N. Y.*

Reciprocating Machine: Di-Profiler is driven by a flexible shaft having standard connections. Has controlled stroke, variable from 0 to ¼-in. Speed of reciprocation can be varied from 0 to 100 strokes per second. For filing, lapping, scraping, honing and polishing; claimed to be especially advantageous for honing and lapping straight


AIR COOLED COUPLINGS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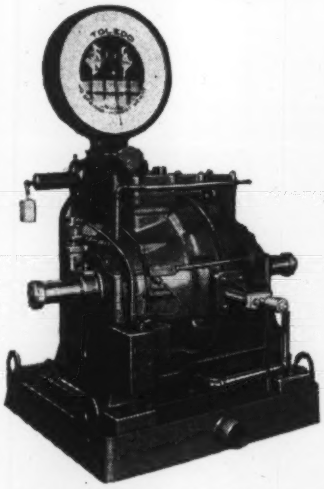
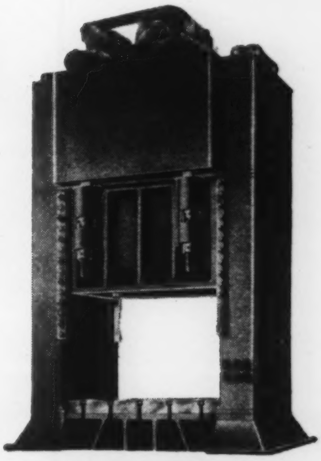
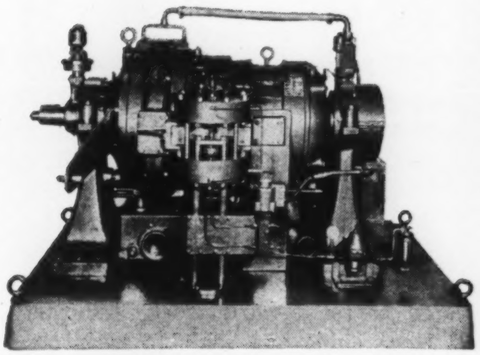
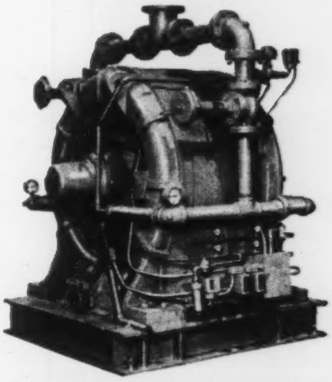


ABSORPTION DYNAMOMETERS


PRESS DRIVES

WATER
OUTLET
LIQUID COOLED COUPLINGS


UNIVERSAL DYNAMOMETERS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DYNAMOMETERS

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and curved surfaces, reworking hardened materials, finishing complicated dies and molds and regular or irregular drawing dies, and for precision lapping of small holes. Vibration-free; easily controlled during operation. Weighs less than 1 lb. *Engis Equipment Co., Chicago, Ill.*

Sander-Polisher: Model No. 966 for sanding, polishing, buffing, drilling and light bench grinding and wire brush work. Universal motor operates on 115 volts, either ac or dc. Attachments such as 1/4-in. capacity keyed Jacobs chuck, orbital-motion fine sander and bench stand and wheel arbor, as well as accessories, are available. *Syntron Co., Homer City, Pa.*

Electronic Gun: Quick-Hot tool for cutting plastic tiles in any shape. Heats in 3 seconds and cools quickly when trigger is released. Built-in spotlight automatically illuminates work. Handle and case are heat and shock-resistant. Can also be used for soldering by changing tip. *Wen Products Co., Chicago, Ill.*

Weld Flux Scaling Hammers: Air operated, small, lightweight. Deliver required speed and power for removing flux and splatter after welding. Especially suited for corner welds and one-hand operation where space is limited. Exhaust air, blown from four holes in front of barrel toward work, removes loose chips and scale to maintain surface visibility. Other applications include paint scraping, rust removal, wood chiseling, small casting sand removal and mold cleaning. Three models available: Size 5L with lever throttle, Size 5P with push throttle and Size 5B with button throttle. Straight, angle or mortar chisels may be used. Measure 7¾ in. long, weigh 2⅛ lb *Thor Power Tool Co., Aurora, Ill.*

Power Plant Equipment

Electric Plant: Model 1A21 generates 1000 watts. For various portable and semiportable jobs. Three models — automatic, which starts and shuts down as the load requires, portable, and pushbutton —are available for either gasoline

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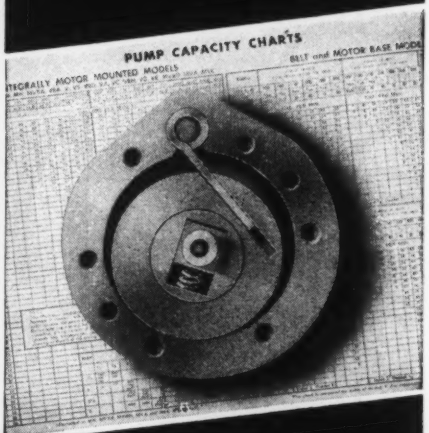

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"What was the old way?" asked Mac, who'd recently started in at the shop.

"Well, it was a one-two-three operation. We used to machine the slotted-head screw for the clamp on that machine over there. Then we'd make a special collar, and fit it around the screw head to prevent the screw-driver from slipping out of the slot while the clamp was being applied or adjusted.

"What RB&W did was to cold-form the whole thing—screw, slot and collar—all in one piece. Wasn't an easy job, either—they had to strike a slot in the screw head and form the collar at the same time. Now we're saving one-third on our previous assembly costs—along with the price of the special collar."

Which proves that you can generally cut costs, if you look hard enough . . . even in such simple things as fasteners. It also underlines the creative approach to fastening problems you can expect from RB&W, as well as practical experience in designing and fabricating. If the fastener you need can't be supplied from our extensive stock, we'll study your assembly operation and make the right one for the job.

Remember—for any fastening operation, it's a smart move to call in RB&W. You can count on RB&W bolts, nuts, screws and rivets for uniform accuracy, dependability and physical properties. And you can also count on fast service from RB&W's strategically located plants at: Port Chester, N. Y., Coraopolis, Pa., Rock Falls, Ill., Los Angeles, Calif. Additional sales offices at: Philadelphia, Pittsburgh, Detroit, Chicago, Dallas, San Francisco. Sales agents at: Portland, Seattle. Distributors from coast to coast.

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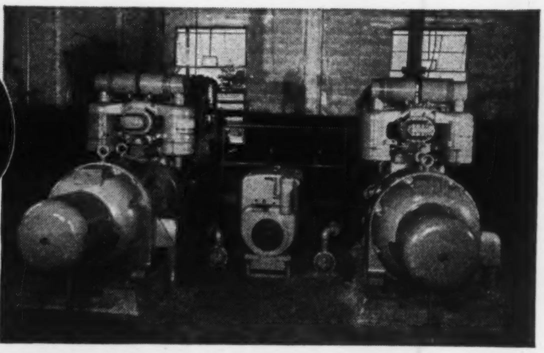

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or natural gas operation. All models feature elimination of interference with radio; voltage and frequency regulation permits satisfactory operation of fluorescent lights, radio equipment, public address systems and movie projectors. *Kohler Co., Kohler, Wis.*

Outboard Motor: Mercury 5-hp engine features new type of neutral clutch which permits starting the motor while in neutral gear. Positive-engagement clutch is operated from a pushbutton recessed in front of safety-tilt handle on top of motor. Operation of pushbutton halts the propeller but allows the engine to continue operating. Motor also features full reverse, 360-degree steering with automatic safety lock while in reverse; antifriction ball and roller bearings. Weighs 40 lb. *Kiekhaefer Corp., Fond du Lac, Wis.*

Processing

Die Casting Machine: Model 1500 has capacity of 1½ lb zinc. For high-speed production of small castings and short runs. Air-operated; capable of a free-cycling speed exceeding 1000 shots per hour. Features electronically controlled panel, 10 by 10 by 2½-in. die blocks, four tie bars and semiautomatic cycling with adjustable timing dwell on opening and closing of the toggle. Specifications include: die thickness standard two halves, 5 in., maximum, 7 in.; die locking pressure, 20 tons; die opening, 4 in.; plunger at 1500 psi, 1⅝ in.; pot capacity, 275 lb zinc; operating air pressure, 100-125 psi; electric power 110-125 volts ac. Size of machine: 66 in. high, 27 in. wide, 80 in. long; weight, 200 lb. *ABC Die Casting Machine Co., Chicago, Ill.*

Lubricant Applicating Machine: Designed especially for the application of dry lubricant to sheets and blanks. Can process materials at speeds up to 55 fpm. Sheets or blanks to be coated enter washer unit and are cleaned by rotary brushes and an alkaline cleaner. Brushes contact both top and bottom of material during wash and rinse stages. Cleaned stock then

Standard Oil Company's Newest, Safest Aircraft Refueler is using

BERRY *Rotodraulic*

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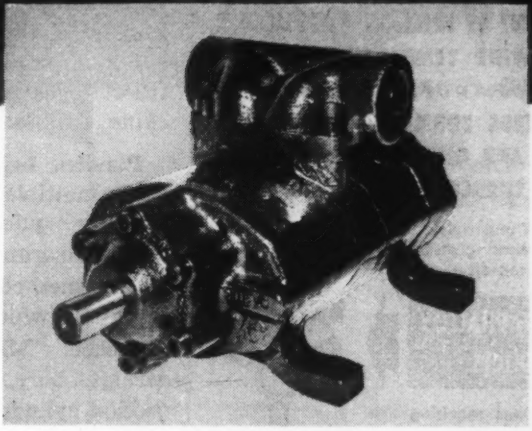

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In a Berry hydraulic transmission, driven by power-takeoff, a new and safer way was found to drive the gasoline pump.

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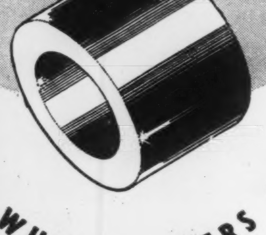

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enters self-contained coating unit horizontally to permit easy loading and stacking. Steam-heated, fully enclosed solution tanks can handle blanks up to 48 in. wide. After coating, stock enters drying element, which is available with steam, gas or electrically heated ovens. Dry coated material is claimed to be clean and easy to handle; can be stored safely for long periods and then formed without additional lubricant. *Gilron Products Co., Cleveland, O.*

Centrifugal Casting Machine: Available in six sizes, covering a casting range from 1 in. ID to 16 in. OD and up to 60 in. long. Uses permanent molds made of ordinary steel tubing. Molds can be removed from machine to change casting size by opening hinged top cover. Runner pot is mounted on hinged front door, eliminating the necessity of aligning pot with the mold after removal of each casting. Mold is cooled by water sprays; complete control of mold temperature is maintained. Gray iron, cylindrical castings can be produced in hot metal molds held at a controlled temperature. Machine is particularly suited to production of bushings or cylinders of gray iron, steel, bronze and aluminum, either in production or small quantities. *Centrifugal Casting Machine Co., Tulsa, Okla.*

Plastics Injection Molder: Features multiple packing of injection cylinder, quick mold release for nozzle clearance and new "Hydra-Lock" method of clamping molds together which exerts 200 tons pressure. Machine employs a straight bore, externally heated injection cylinder. Material is packed into heating section by multiple injection strokes, compressing the material, reducing bulk factor and insuring maximum injection. Injection of material into mold is compensated electrically. Injection pressures adjust to a maximum of 20,000 psi. Toggle mechanism serves as a mechanical locking device to hold the platen in the closed position. Hydraulic cylinder accomplishes final closing of molds and supplies final locking pressures. Molding cycle starts by

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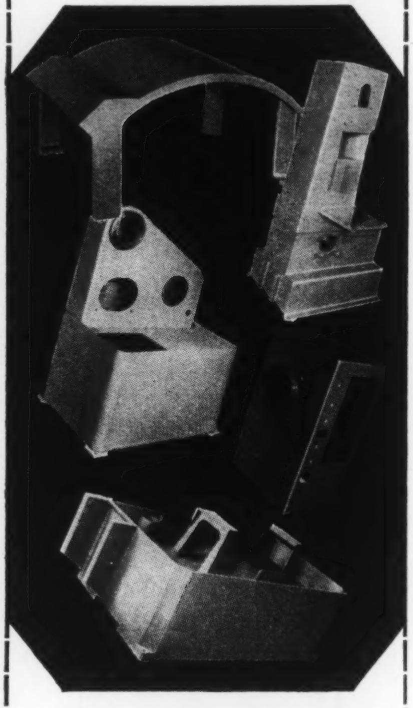
WELDMENTS BASES AND SUB-ASSEMBLIES



Weldments, Bases and Sub-Assemblies fabricated by Littleford give Economy, Strength, Permanence, Adjustability and Low Cost. Fabricated Products speed up production by eliminating machining operations and expensive patterns. To produce modern plate and sheet metal products also requires experience and skilled craftsmen; this is where Littleford definitely fits into the picture. Since 1882 Littleford has developed craftsmen to shear, bend, form, weld and finish plate and sheet metals. Using modern methods and modern machines, Littleford Weldments, Bases and Sub-Assemblies are the last word in accuracy.

FABRICATORS OF PLATE AND SHEET METAL PRODUCTS FOR INDUSTRY SINCE 1882

If you have a problem involving Weldments, Bases or Sub-Assemblies, remember there is no substitute for experience, send your blueprints to Littleford, see how skill can produce low-cost products.

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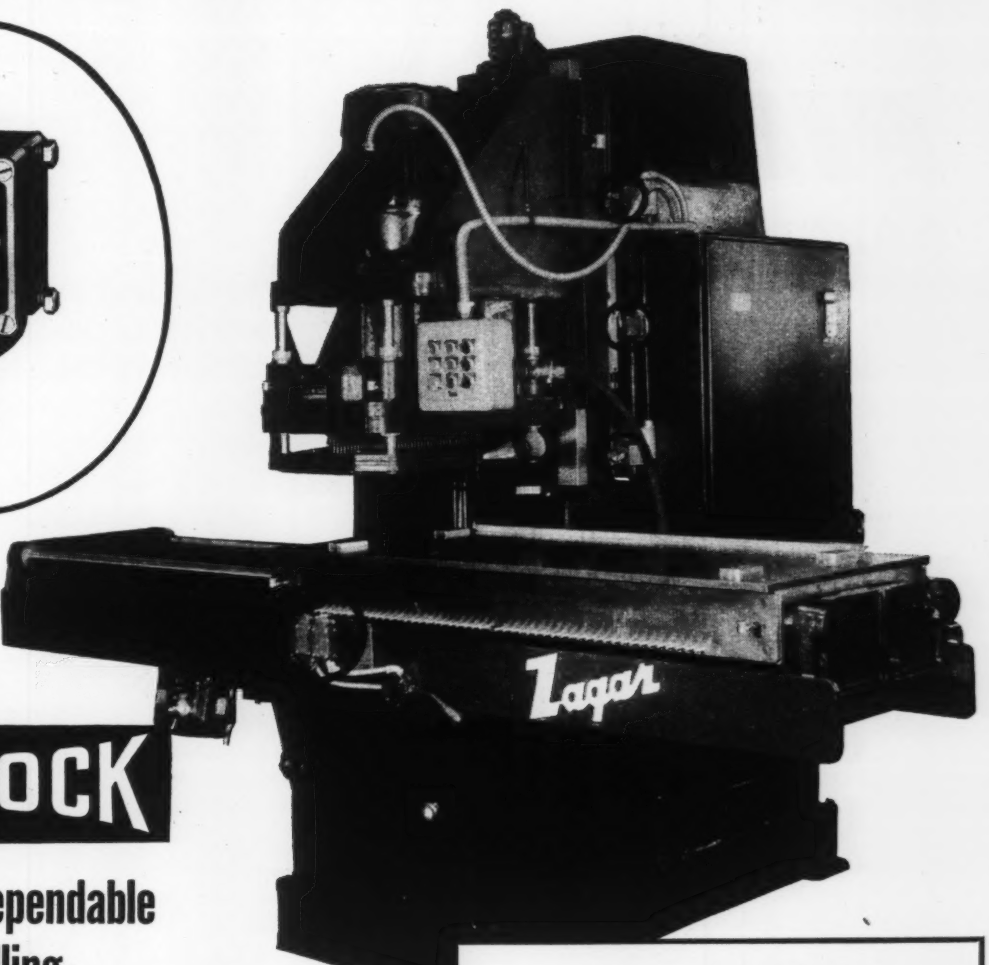
LITTLEFORD BROS., INC.
424 E. Pearl St., Cincinnati 2, Ohio

for jobs where you "can't take chances"...

SNAP-LOCK
SWITCH
No 160-1200
THE NATIONAL ACME CO.



SNAP-LOCK
TRADE MARK

again proved dependable for controlling repetitive cycles at 60 passes per minute

This Zagar acoustical wall tile drilling machine employs 5 Snap-Lock limit switches—three automatically controlling movements of the 96 spindle drill head and two actuating the hydraulic system operating the work table.

Zagar Tool Inc., Cleveland, O., manufactures drill heads, drilling and broaching machines. After 10 years experience with Namco Snap-Lock limit switches applied to a wide variety of large and small machine tools, Mr. Frank Zagar, General Manager states—

> **"for the fast, exacting and dependable controls in our machines, we can take no chances—we recommend Snap-Locks to customers all over the country"**

This confidence is typical of expressions from machine tool builders, 90% of whom have adopted Snap-Locks as standard built-in equipment—some using more than 200 units on a single installation.

You can depend on Snap-Lock—Ask your Engineers to contact ours. Specifications Bulletin EM-51.

HEAVY DUTY FEATURES OF SNAP-LOCK LIMIT SWITCHES

built BY machine tool builders FOR machine tool builders

- Separate safety walled enclosures for electrical and mechanical sides.
- Hardened steel parts, rugged, compact.
- Heavy insulation, oil and dust resistant case.
- Positive lock in "on" and "off" positions.
- Single pole, normally open and closed, double break contact arrangements.
- Self wiping coin silver contacts.
- Wide variety of standard mountings and operating levers.

ELECTRICAL MANUFACTURING DIVISION

The NATIONAL ACME COMPANY

180 EAST 131 STREET, CLEVELAND 8, OHIO

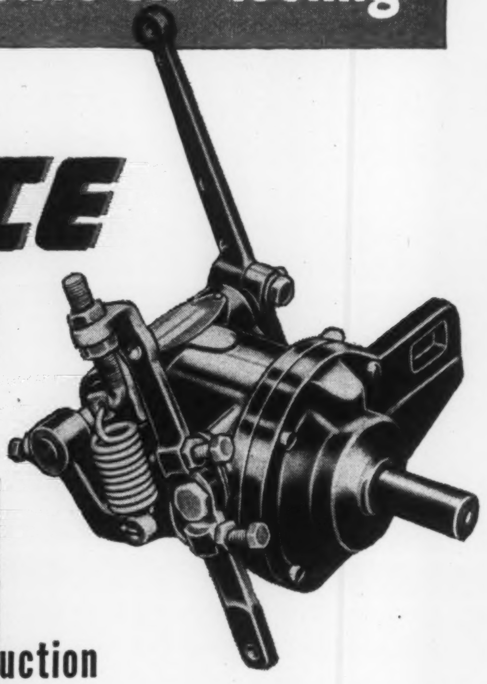
Acme-Gridley Bar and Chucking Automatics: 1-4-6 and 8 Spindle • Hydraulic Thread Rolling Machines • Automatic Threading Dies and Taps • Limit, Motor Starter and Control Station Switches • Solenoids • Contract Manufacturing

you can save on "tooling"

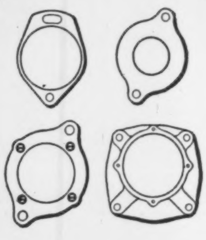
with

PIERCE

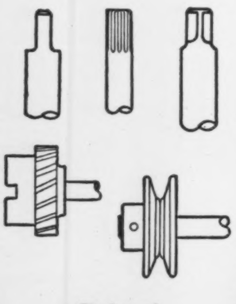
GOVERNORS



standard parts
now in production
will meet most requirements for your engine



Choice of Many Mounting Flanges



Choice of Many Drives

Pierce Governors, assembled from standard parts now in production, can equip your engine for virtually any speed control requirement—without the delays and costs of special design or tooling.

During the past 40 years Pierce has built governors and parts for almost every gasoline engine application . . . and has existing tools and parts to give you a suitable governor at a worthwhile saving.

Basic governor bodies (such as 900 Series shown above) equipped with your choice of mounting flange and drive (also production parts) may be assembled to give you either long-range *variable* or *constant* speed control. Control levers in a great variety of shapes and sizes are available.

PIERCE offers you a ready solution to most gasoline engine governing problems. Send full details and specifications to

The Pierce Governor Company, Inc.
1606 OHIO AVENUE
ANDERSON, INDIANA

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"WORLD'S MOST EXPERIENCED GOVERNOR MANUFACTURER"

closing of safety gate. Platens advance automatically, "Hydra-Lock" cylinder closes mold and material is injected. During curing cycle, prepack of injection cylinder takes place. Molds open automatically at conclusion of cycle and remain open for removal of finished part. Suggested for use in toy, container, novelty, automotive, radio-television, electrical and mechanical small parts industries. *Lewis Welding & Engineering Corp., Bedford, O.*

Electric Oven: Model PL 2A is portable; has eight compartments which allow for separation of different sizes or types of products while drying, baking or preheating. Features low operating cost, adjustable temperature control to 325 F, fan-driven forced circulation of air which forces moisture out, and adjustable damper for temperature control. Suitable for moisture stabilization and storage of low-hydrogen, stainless steel, hardenable steel and other welding electrodes. Size: 30 by 25 by 24 in.; inside of oven measures 28½ in. wide, 24 in. deep, 20½ in. high. *Grieve-Hendry Co. Inc., Chicago, Ill.*

Blasting Machine: Jet Blast liquid abrasive machine cleans, finishes, burrs, blends or etches variety of dies, molds, tools and other parts. Liquid slurry is drawn up by siphon injection and propelled from blasting nozzle by means of high-velocity air stream. Only moving part within cabinet is blower, which ventilates the cabinet. Machine handles abrasives ranging from 60 to 5000 standard screen size. Reversible pump located beneath cabinet effects complete change-over of abrasive slurry in less than five minutes. Method of maintaining slurry in suspension permits higher concentration of abrasive at point of work. Removes rust, scale and other deposits and produces clean matte surface. Can effect any desired finish on flat or irregular surfaces. Metal removel can be held to 0.0001-in. Can be used for light burring, honing cutting faces, and for blending or removing directional grinding lines or tool marks on machined surfaces. Available

Which Carburizing Grade of Tubing Is Best for You?

...B&W Can Supply Them All

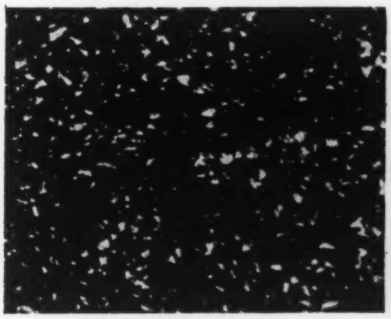
When you want to carburize for hard surface and at the same time maintain a tough core, it is wise to examine all available carburizing grades to determine which is most suitable for your specific operation. The low-carbon alloy steels listed are typical of those designed for ease of carburization.

After carburizing, the steel has a high carbon content on the surface and only the carbon content of the base alloy in the core. This provides, after suitable heat treatment, a surface which is hard and wear resistant and a core that is tough and ductile—a combination desired in many applications. Alloying elements impart an ability to develop a deeper case for a given set of carburizing conditions and provide a more gradual transition in microstructure and hardness from case to core than in a plain carbon steel.

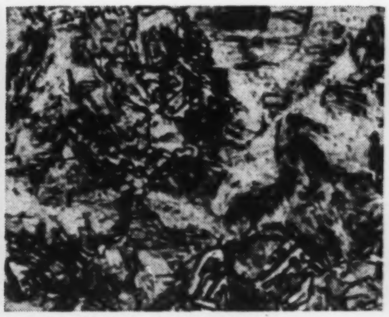
In the application of these low-carbon alloy steels it is possible, in many instances, to use alternate grades without loss of desirable mechanical properties. Discuss your requirements with Mr. Tubes—your nearby B&W Tube Representative. You'll find B&W Bulletin TDC-149 helpful, too. Write for it.

TYPICAL GRADES

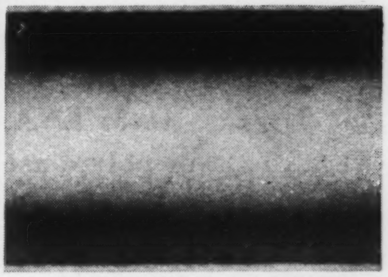
1320
2317
2515
3120
E3310
4023
4320
4620
4815
5120
6120
8620
8720
E9310



Microlat 1000X of the case



Micro at 1000X of the core



Macro of the tube wall at 5X

THE BABCOCK & WILCOX COMPANY
TUBULAR PRODUCTS DIVISION

Beaver Falls, Pa.—Seamless Tubing; Welded Stainless Steel Tubing
Alliance, Ohio—Welded Carbon Steel Tubing

B&W SEAMLESS and WELDED TUBES

TA-1746 (C)

Diversatility Defined...!

ANY CONTROL ASSEMBLY
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PIPE SIZES—
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We take pleasure in offering you the services of these representatives. They are pneumatic specialists — *every one of them.* Phone the nearest one for information and expert help on your air control problems.

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Eureka — Bearings & Transmission Prod.
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Connecticut
Hartford — Gibson Eng. Co.
Georgia
Savannah — Air Products Co.
Illinois
Chicago — Walter Norris Eng. Co.
Indiana
Logansport — Tec Eng. Co.
Massachusetts
Boston — Gibson Eng. Co.
Michigan
Detroit — William Finn
Minnesota
Minneapolis — John Henry Foster Co.
Missouri
Kansas City — Ellis Akin Eng. Co.
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New York
New York City, Newark —K. E. Knotts Co.
Buffalo, Rochester, Syracuse — R. C. Neal Co.
Ohio
Cleveland — P. W. Rice
Dayton — K. C. Mosier
Oregon
Portland — Power Transmission Prod.
Pennsylvania
Glenside — J. Boyd Coates
Pittsburgh — Ralph A. Hiller Co.
Texas
Houston — Hydraquip Corp., Wendler Co.
Washington
Seattle — Chain Gear, Inc.
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Specialists in SMALL quantities of custom built transformers from milliwatts to 50 KVA, single or polyphase—designed and manufactured to best meet your exact requirements.

Each Electran Transformer is built to the highest standards of quality and precision. There is no "second" grade at Electran.

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in three standard models; special sizes can be furnished. *R. W. Renton and Co., Cleveland, O.*

Testing and Inspection

Collimator: G-12 Goniometer checks collet and lathe tool angles and measures bedway flatness to within 0.00007-in. Can be used with accuracy by semiskilled workers. Does not require sine bar set-up techniques nor calibration. Is self-checking and eliminates necessity of jigs and fixtures. Can be clamped to any support, without special mounting. Measures continuously and can incorporate engineering changes without requiring gage work. Parts can be checked at an inspection rate of several per minute to a sensitivity of less than 0.002 degrees. Can also be used in deep and narrow recesses; checks angles on flat as small as 0.004-sq in.; can set up an angle or surface using any plane surface as reference, even if reference is 20 ft away. *Safe Flight Instrument Corp., White Plains, N. Y.*

Environmental Tester: High and low-temperature equipment provides conditions for most temperature testing requirements including physical, weathering and aging tests. Comprised of separate air conditioning Servo unit and companion test chamber. Attachment will maintain relative humidity from ambient to 95 per cent in temperature range from ambient to 180 F. Portable Servo unit can be connected to laboratory enclosures to provide circulation of 40 cu ft per minute. At −100 F, circulation will absorb 1700 Btu of heat per hour, and at temperatures to 185 F, circulation can deliver 5000 Btu heating effect. Low temperatures are achieved by circulating air over dry ice; high temperatures, by circulation around electric heaters. Servo units available in two sizes—17 by 17 by 31 in., weighing 165 lb, with dry ice capacity of 50-70 lb and 21 by 25 by 33 in., weighing 200 lb, with dry ice capacity of 150 lb. Temperature range of both models is −100 to 200 F. Insulated companion test chamber has stainless steel liner, inspection window on door. Door can be installed to hinge upward or to one side. Chamber available in 3, 8 or 26 cu ft sizes. *Tenney Engineering Inc., Newark, N. J.*

Hydraulic Test Stand: Determines physical characteristics of any seamed tubing up to 3-in. diameter. Checks test specimens of steel, stainless steel and carbon steel tubing for flaring, column and crushing strength with pressures up to 100,000 lb. For testing electric-welded tubing used in the manufacture of boilers, furniture, power transformers of tubular tank construction, heat exchangers for exhaust gas coolers, etc. Self-contained unit requires connection to 60 to 80-lb air supply. Operation is by solenoid, pushbutton control after test specimen is inserted between fitting anvils. *Dommers Co., Wallingford, Conn.*

Universal Testing Machines: New models of 60-H and 12-H machines; have 60,000 and 12,000-lb capacities. Clear space between column is increased from 10 to 15 in., machines are of single instead of two-unit design, and both are available with either precision Emery 16-in. diameter indicator dials or Tate Emery indicator with three ranges on one 24-in. dial. Both machines feature rigid loading systems consisting primarily of two cages. Load, either in tension or compression, is applied upward by a movable cage composed of table of machine and two columns supporting upper gripping head. This cage is attached to the piston in a hydraulic cylinder in machine's base and has a 6-in. stroke. Loading speed varies infinitely between 0 and 2 in. per minute on the 60-H and between 0 and 4 in. per minute on 12-H model. Lower gripping head is upper member of second cage, including two long columns which reach down through the table to a lower crosshead supported by a vertical screw extending downward from center of the stationary hydraulic cylinder. Lower gripping head can be adjusted at 10 in. per minute through range of 17 in. Adjustment provides vertical space of 1 to 18 in. for both

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I KNOW THINKS
OSBEAR
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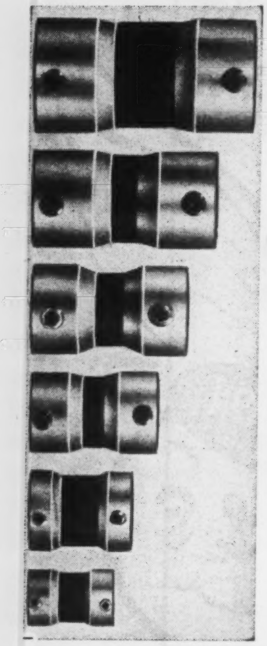
O&S BEARING & MFG. CO.
777 W. EIGHT MILE ROAD • WHITMORE LAKE, MICHIGAN

There's a
*Dyna-Line
FLEXIBLE COUPLING
to FIT YOUR DRIVE!



1/15 to 1-1/2 Horsepower

Min. Length 1" to 2-3/8"

Lengths to Your Drive Design Needs

SPECIFY Guardian FOR BEST PERFORMANCE OF YOUR EQUIPMENT . . .

*Exclusive Guardian Dyna-Line construction produces a superior one-piece flexible power connector by joining the three components into one unit while they are spinning and held in dynamic alignment.

In these couplings, the length of Flex-Element specified enters the function of needed adjustment to misalignment, or of added torsional damping. Exceptional lateral flexibility with minimum stresses imposed and torsional stability retained are controlled design features.

Exclusive manufacturers of the Guardian Splined Sleeve Coupling (now with Silent Tension), for years the standard coupling for the Oil Burner Industry.

Write for C-102 Catalog Page, also Drive Data Form #53 for coupling recommendations.

Put a GUARDIAN Here YOUR UNIT

Guardian
PRODUCTS CORP.
COUPLING DIVISION
Dept. IC-M, 1215 E. Second Street
Michigan City, Indiana

tension and compression tests. Size of both machines: 67½ in. wide, 27 in. deep, 77½ in. high overall. *Baldwin - Lima - Hamilton Corp., Philadelphia, Pa.*

Transportation

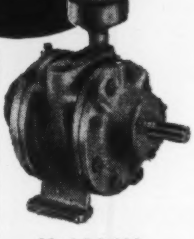
Motor Scooter: DeLuxe Highlander model cruises at speeds up to 35 mph, runs 75 miles per gallon of gasoline. Features include welded steel frame; extra strong front fork assembly; oversize, adjustable tapered-roller wheel bearings; shock absorbing springs; automatic disk clutch; heavy-duty brake; heavy weight roller chain drive; double baffle muffler. *Cushman Motor Works Inc., Lincoln, Neb.*

Trucks: New line features large, one-piece curved windshields with swept back pillar posts and 55 per cent greater visibility. Synchro-silent transmissions eliminate double clutching. Shorter wheelbases, wider front treads and repositioned springs afford easier handling and steering, more maneuverability and shorter turning radius. Have 4-ft wide rear windows, 5-ft wide seats, counter-shock seat snubbers which absorb road shocks, easy accessibility for servicing. Engines range from 101 to 155 hp. Automatic transmissions or automatic overdrive available for all models as optional equipment. *Ford Div., Ford Motor Co., Dearborn, Mich.*

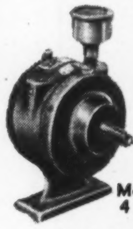
Tandem Truck: Designed for transit concrete mix or dump bodies. Available in 150 to 203-in. wheelbases. Can haul one-third heavier loads within existing weight limitations—accommodates 6 yd of concrete, compared to normal load of 4½ or 5 yd. Body and payload center of gravity are sharply forward, which places more load on the front axle. Truck has a 14,000-lb front axle, extra heavy progressive type front springs and full integral power steering. Powered by gasoline engine; liquid petroleum gas engine is optional. Has adjustable seat, improved visibility, 50-gal gasoline tank. *Reo Motors Inc., Lansing, Mich.*

Get astonishing POWER and other unique advantages with GAST rotary AIR MOTORS

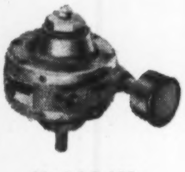
Model 1 AM
Up to 1/6 H.P. —only 2½" dia., weighs 1½ lbs.



Model 8 AM
Up to 4 H.P.—only 6½" high (less muffler)



Model 4 AM
Up to 1 H.P.—only 5¾" high (less muffler).



Model 2 AM
Up to ½ H.P.—weighs approx. 5¼ lbs.

FOR YOUR ORIGINAL EQUIPMENT APPLICATIONS . . .

Gast rotary-vane Air Motors may solve tough problems on **your** product! They're lower in first cost, variable in speed, explosion-proof, quick starting, **amazingly** compact and light compared to electric motors.

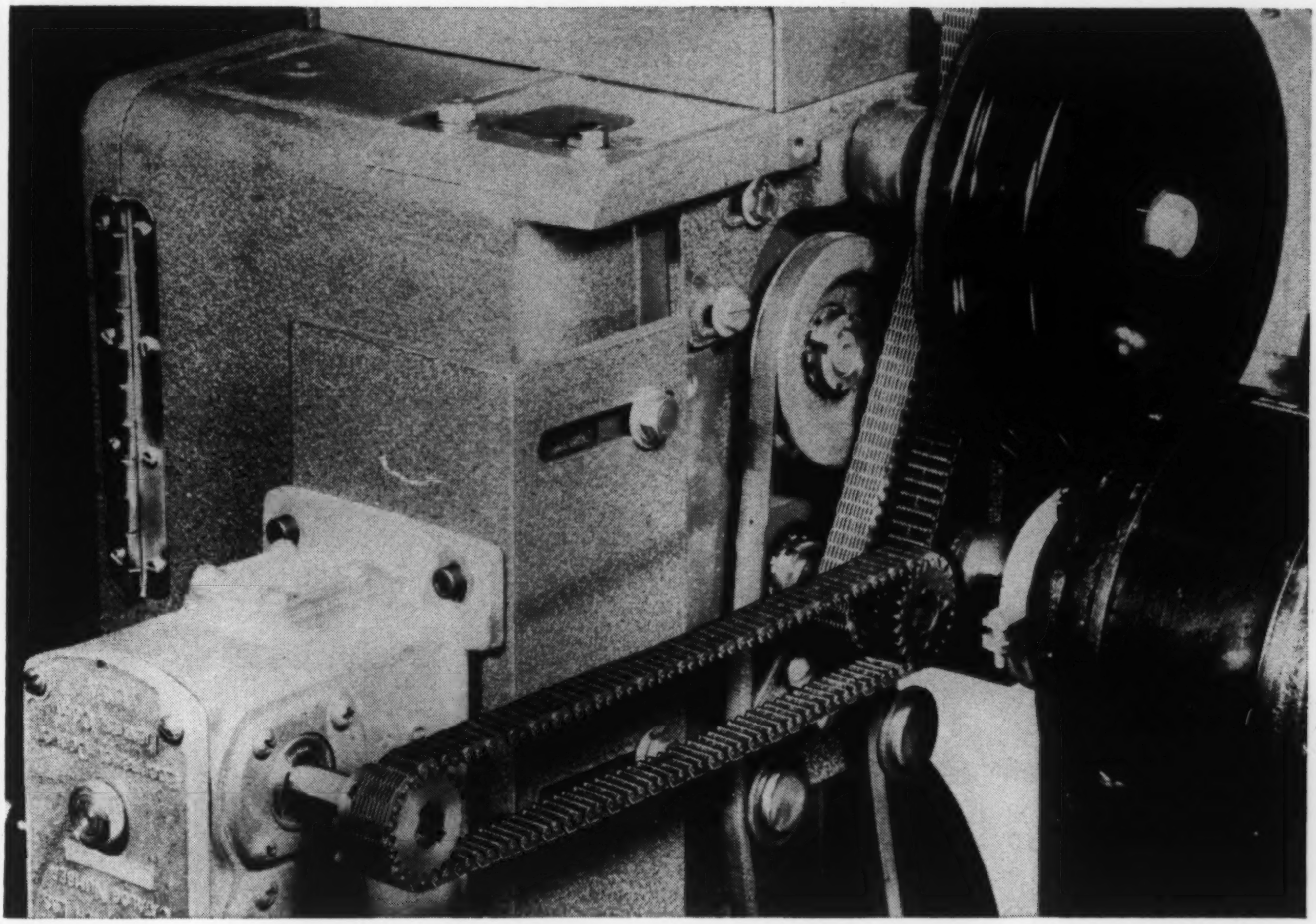
Four sizes available, reversible and non-reversible ball bearing types, several mounting styles, speeds to 12,000 RPM. Numerous accessories. "Air may be your Answer!"

see our CATALOG in SWEET'S FILE for product designers

Write Gast, stating your specific problem or mention model that interests you.

Original Equipment Manufacturers for Over 25 years

GAST ROTARY
AIR MOTORS (TO THREE H.P.) - COMPRESSORS (TO 30 LBS.) - VACUUM PUMPS (TO 28 INCHES)
GAST MANUFACTURING CORP., 107 Hinkley St., Benton Harbor, Mich.



Mechanical Interlock for 3-D movie projectors achieves perfect synchronization between two projectors through use of Morse Silent Chain Drives.

Precision-built Morse Silent Chain Drives synchronize 3-D motion pictures

Three-dimension projection by the Natural Vision Process requires two projectors, operating simultaneously.

To interlock these projectors perfectly, Motiograph, Inc., uses Morse Silent Chain Drives.

For over fifteen years, Motiograph, which manufactures 35 mm. motion picture projectors and sound systems, has used Morse Silent Chain Drives to couple its projectors with its sound-reproducing systems and provide perfect synchronization.

If you have a problem involving delicate mechanical synchronization, check into Morse precision-built Silent Chain Drives. Smooth, positive action reduces slippage losses and load on shaft bearings. The exclusive Morse Rocker-Joint construction converts sliding action to rolling motion, results in 99.4% power-transmission efficiency. They're compact, unaffected by atmospheric conditions. Give unusually long trouble-free service life.

Let us give you detailed information on Morse Silent Chain Drives for power transmission from fractional horsepower to over 1000 horsepower. Write Morse Chain Company, Dept. 483, 7601 Central Avenue, Detroit 10, Michigan.

M=PT
MORSE
means
POWER TRANSMISSION

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EXCEPTIONAL PRODUCT LIFE

and
EXCEPTIONAL PRODUCT QUALITY

MORSE
BW
MECHANICAL
POWER TRANSMISSION
PRODUCTS

Chance Vought F7U Cutlass

Here's a simple equation:

NO HIGH ALLOY STEEL = NO PLANE

Without stainless steel, super-high-temperature steels and special electrical alloys, it just wouldn't be possible to build, power and control a plane in the over-600-miles-per-hour class. That is our job: to develop and produce such metals . . . and if you have any problems that involve resisting corrosion, heat, wear and great stress, or require special magnetic properties, we're the people to see. *Allegheny Ludlum Steel Corporation, Oliver Building, Pittsburgh 22, Pa.*

PIONEERING on the Horizons of Steel

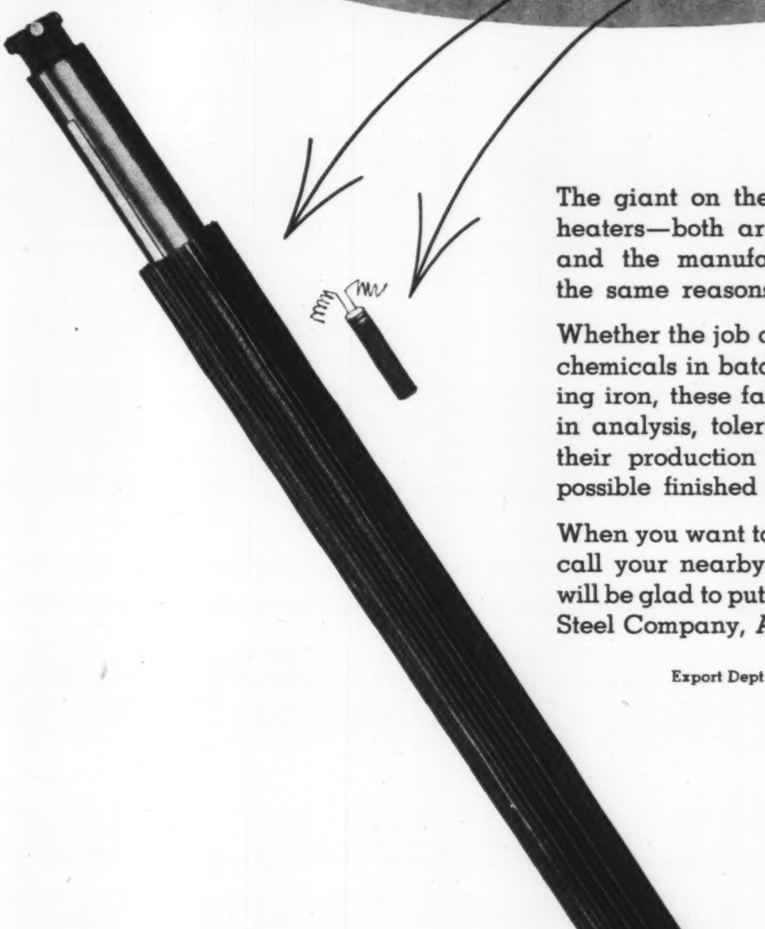
Allegheny Ludlum

Warehouse stocks of A-L Stainless carried by all Ryerson plants

AL
LEADING PRODUCER HIGH-ALLOY STEELS

W&D 4102 B

Whether the job is BIG or small uniform *Carpenter* tubing speeds fabrication



The giant on the left and the pygmy on the right are both heaters—both are made from Carpenter Stainless Tubing—and the manufacturers selected Carpenter for essentially the same reasons.

Whether the job calls for a large immersion heater for heating chemicals in batch tanks or a small heating unit for a soldering iron, these fabricators know that the consistent uniformity in analysis, tolerance and finish of Carpenter tubing makes their production move smoothly and gives them the finest possible finished product.

When you want to discuss your design or fabricating problems, call your nearby Carpenter Stainless Tubing Distributor. He will be glad to put his experience to work for you. The Carpenter Steel Company, Alloy Tube Division, Union, N. J.

Export Dept.: The Carpenter Steel Co., Port Washington, N.Y. "CARSTEELCO"

Carpenter

STAINLESS TUBING & PIPE

Analysis
Tolerance
Finish

- guaranteed on every shipment

In hydraulic pumps

GEROTOR

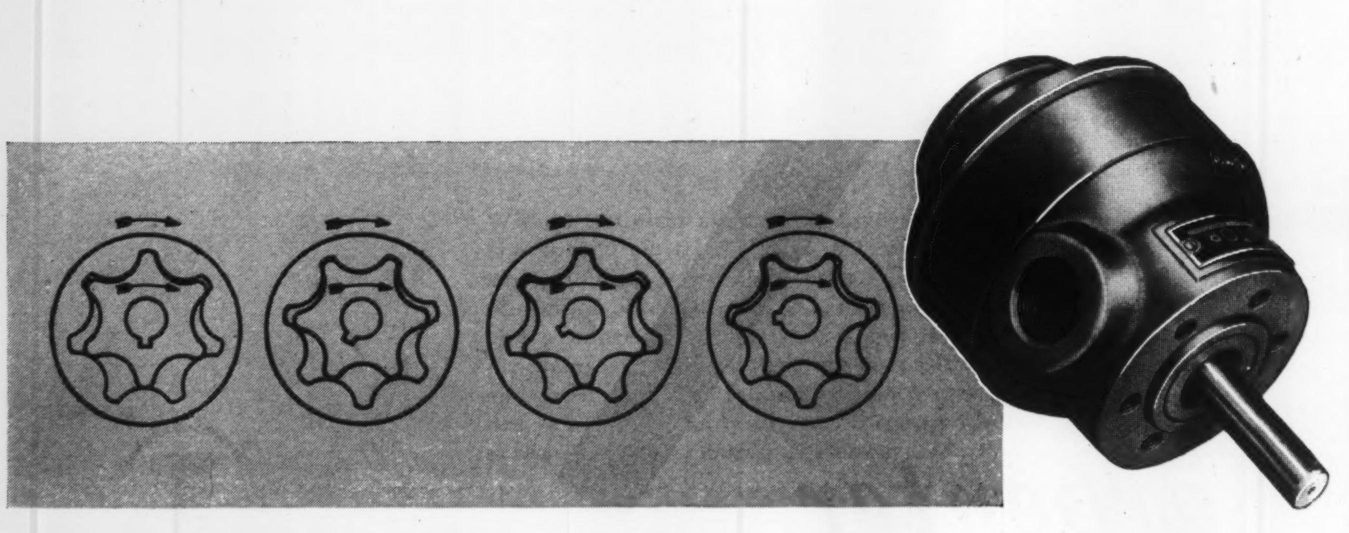
is more than a name . . .

it's the principle of the thing!

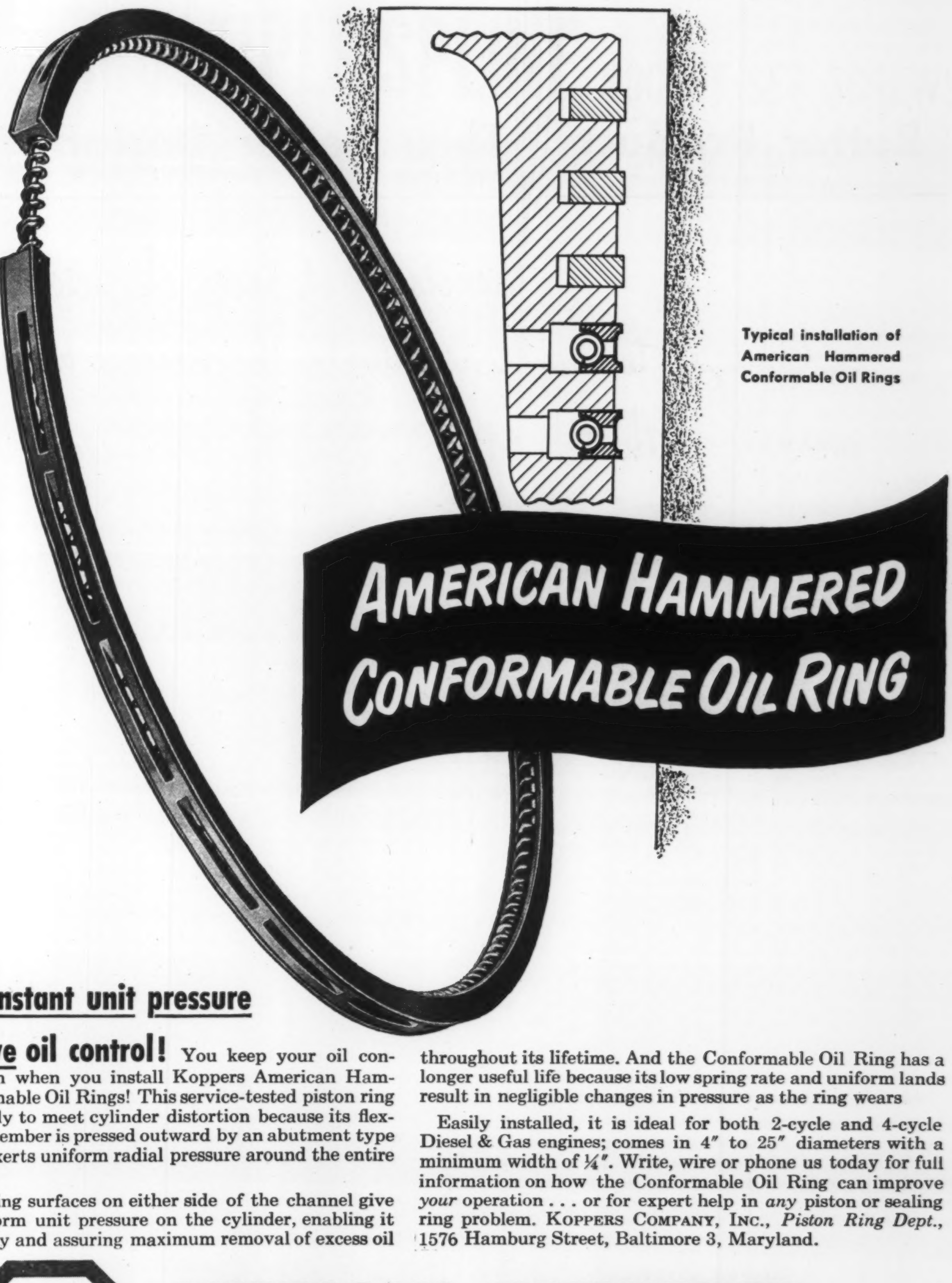
The unique Gerotor principle operates with high volumetric and mechanical efficiency. Both gear-shaped Gerotor elements revolve in the same direction at low relative speed, resulting in less wear, longer life. Continuous fluid-tight engagement means less slippage, more uniform flow. See relative advance of teeth and spaces below.

Gerotor hydraulic pumps are engineered for pressures up to 1000 p.s.i. continuous duty; in some sizes, up to 1200 p.s.i. continuous and 1500 intermittent. Deliveries range from .4 g.p.m. at 1800 r.p.m. to 40 g.p.m. at 1200 r.p.m. Plain, base or flange mounting. Write for pump catalog.

GEROTOR MAY CORP., P. O. Box 86, Baltimore 3, Md.



GEROTOR hydraulic pumps & motors



Typical installation of American Hammered Conformable Oil Rings

Insures constant unit pressure for positive oil control! You keep your oil consumption down when you install Koppers American Hammered Conformable Oil Rings! This service-tested piston ring conforms readily to meet cylinder distortion because its flexible cast iron member is pressed outward by an abutment type spring which exerts uniform radial pressure around the entire circumference.

Narrow bearing surfaces on either side of the channel give the ring a uniform unit pressure on the cylinder, enabling it to seat promptly and assuring maximum removal of excess oil throughout its lifetime. And the Conformable Oil Ring has a longer useful life because its low spring rate and uniform lands result in negligible changes in pressure as the ring wears

Easily installed, it is ideal for both 2-cycle and 4-cycle Diesel & Gas engines; comes in 4″ to 25″ diameters with a minimum width of ¼″. Write, wire or phone us today for full information on how the Conformable Oil Ring can improve *your* operation . . . or for expert help in *any* piston or sealing ring problem. KOPPERS COMPANY, INC., *Piston Ring Dept.*, 1576 Hamburg Street, Baltimore 3, Maryland.

KOPPERS®

AMERICAN HAMMERED

Industrial Piston Rings

METAL PRODUCTS DIVISION • KOPPERS COMPANY, INC. • Baltimore, Maryland

This Koppers Division also supplies industry with Fast's Couplings, Aeromaster Fans, Koppers-Elex Electrostatic Precipitators and Gas Apparatus.

Engineered* Products Sold with *Service

KOPPERS COMPANY, INC., ***Piston Ring Dept.,*** **1576 Hamburg Street, Baltimore 3, Md.**

Gentlemen: Please send me full information on your Conformable Oil Ring.

Name..

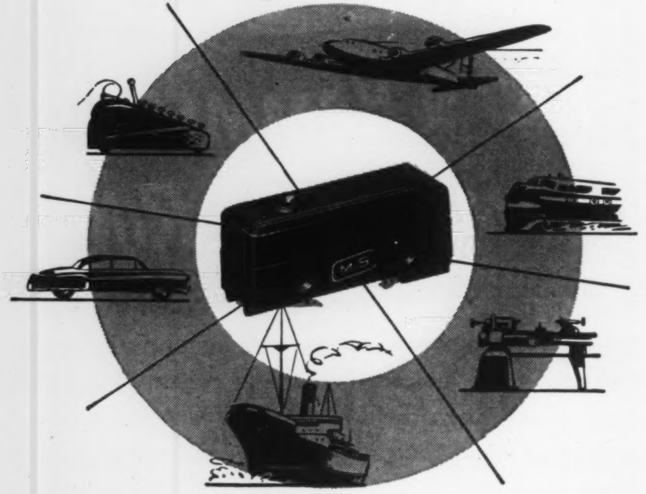
Company..

Address..

City..............................Zone..........State..............................

Better Products Thru Better Design

the vision of research scientists is brought to usable reality by the design engineer working with the MICRO Switch engineer



THE dreams now taking form in the minds of research scientists will become the realities of tomorrow.

Who would have realized that the study of cosmic rays would bring about the Atomic Age? Only a few years ago, skeptics ridiculed the prediction of supersonic speeds. In the last election, people were amazed at the accuracy and speed of electronic calculators.

MICRO switches have always been a part of the atomic program. Supersonic planes are replete with MICRO switches. They are important components of many amazing electronic devices.

What fantastic things are yet to come?

Every day sees new designs made possible by the versatile characteristics of the MICRO switch. Every day sees redesigns, too, that make good products even better by use of these small but dependable switches.

These few brief case histories indicate the degree to which design engineers are convinced that the "use of a MICRO switch is a principle of good design."

* * * *

When you stroll to the diner from your seat on a modern streamlined train, more often than not it is a MICRO switch that opens the heavy door at the touch of your hand. One of the largest makers of these door-opening devices for railroad cars, buses and street cars took advantage of MICRO'S ability to provide small packaged switch assemblies to perform this function. These assemblies eliminated difficult maintenance problems, were easily replaced . . . and opened the doors better.

* * * *

There's a new dictating machine in the market so small that it can be carried in the hand and fits into a brief case. Use of two ultra-small MICRO "subminiature" switches contributed in large measure to the small size and high efficiency of this machine. Hardly longer than a dime and weighing but 1/15th of an ounce, they give the long-life, trouble-free performance such a product must have.

* * * *

MICRO even gives self-control to textile thread. When the bobbin needs refilling on the loom of a well-known manufacturer of textile machinery, a MICRO switch signals the operator in time to avoid thread breakage. This gives a reliability and continuity to loom operation never possible to obtain by mechanical means. The result—better production—smoother operation and happier customers.

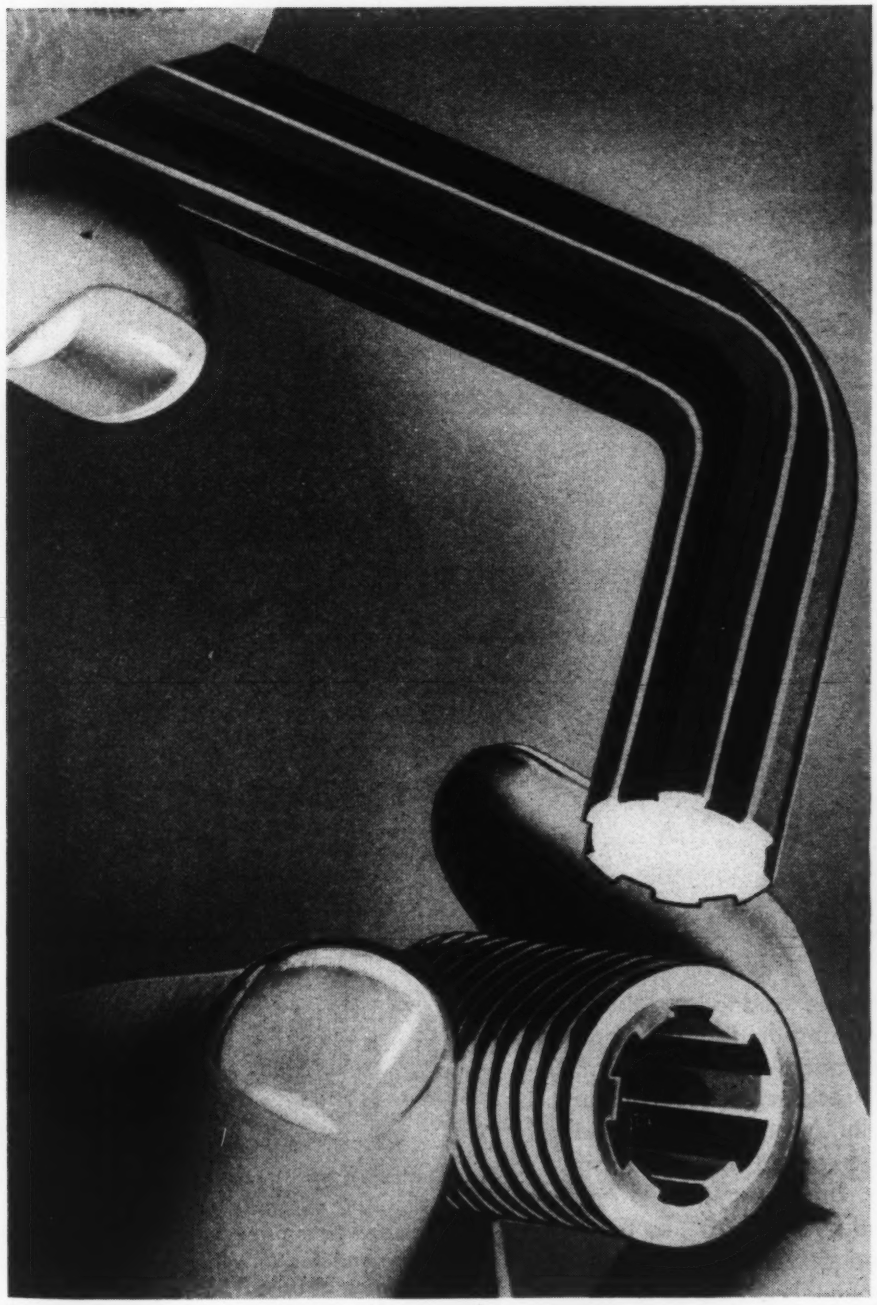
* * * *

More and more evidence piles up that "better products thru better design" can be a reality when design engineers become aware that "the use of a MICRO switch is a principle of good design."

MICRO
MAKERS OF PRECISION SWITCHES
FREEPORT, ILLINOIS
A DIVISION OF
MINNEAPOLIS-HONEYWELL REGULATOR COMPANY

BRISTOL'S MULTIPLE-SPLINE SOCKET SET SCREWS

give far greater HOLDING POWER



The splining principle is recognized by design engineers as the most effective means of transmitting rotary power. That's why it's used in propeller hubs, drive shafts and automobile axles. In Bristol's Multiple-Spline Socket Set Screws, this design results in strength and holding power unequalled by any other screw.

Here are some of the features of Bristol's Multiple-Spline set screws that make them the choice of design, production and maintenance men everywhere . . .

- **greater holding power, permitting use of fewer, smaller screws**
- **easier, faster, and tighter setting**
- **ability to withstand severe shock and vibration**
- **no rounding-out, splitting or breaking under internal wrenching**
- **tamper-proof**

There's no delivery problem with Bristol's Multiple-Spline Socket Set Screws, either. In sizes ranging from No. 2 wire size to ½ inch, all of Bristol's screws are precision-made to conform to Class 3 fit.

Write today for your free copy of Bristol's 40-page catalog on socket screws.

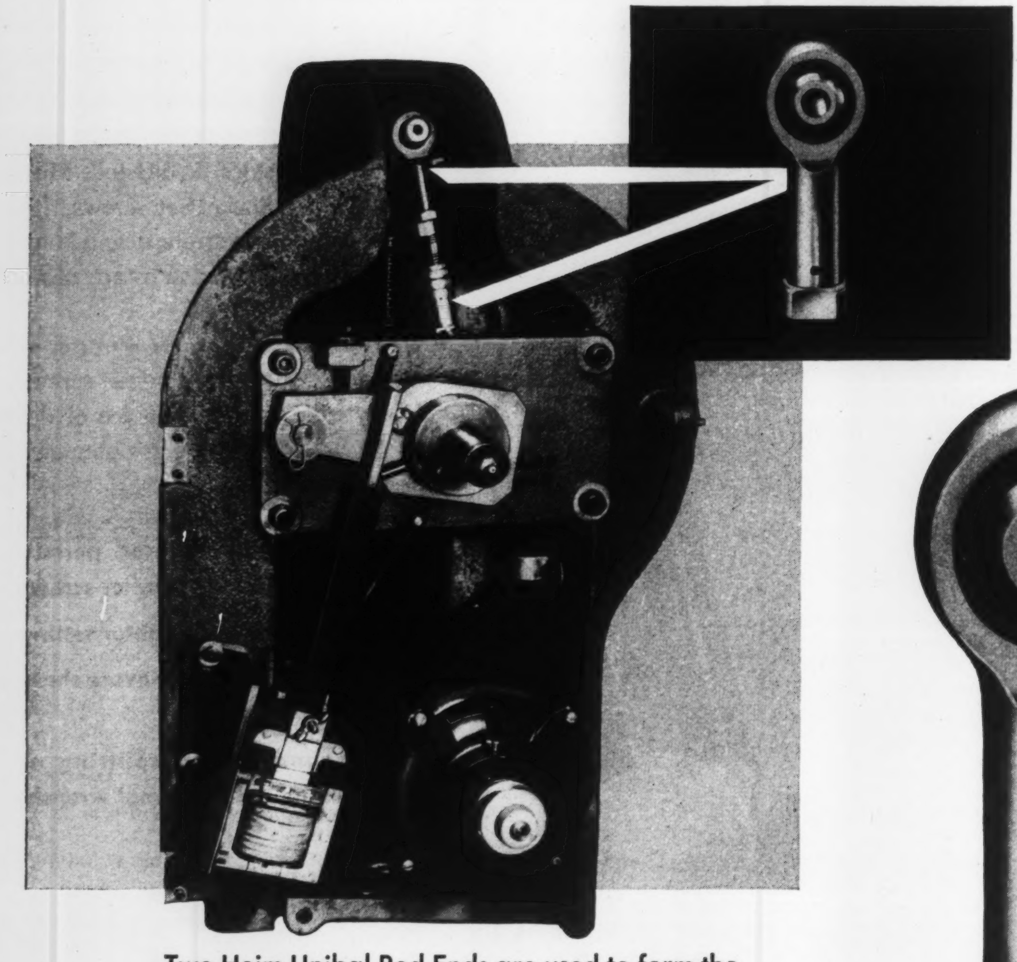
A.3.6

BRISTOL'S SOCKET SCREWS

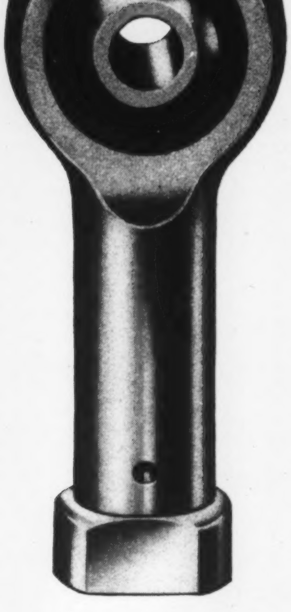
THE BRISTOL COMPANY, Socket Screw Division, Waterbury 20, Conn.

HEIM Unibal Spherical Bearing Rod Ends

HELP TO STREAMLINE DESIGN!



Two Heim Unibal Rod Ends are used to form the link between the crankshaft and the toggle lever on this Amp-O-Lectric Automatic Wire Terminator made by Aircraft-Marine Products, Inc., Harrisburg, Pa. This application of Heim Unibal Rod Ends made it possible to eliminate the exposed crank and ram, streamlined the machine, and permitted turning the crankshaft and flywheel 90°, so that flywheel could be located at rear of machine, and allowed the heavy flywheel and motor to be lowered considerably.



Incorporate Heim Rod Ends in your machine for smoother, improved operation and design. Write for catalog of Unibal Bearings and Rod Ends.

THE HEIM COMPANY

FAIRFIELD, CONNECTICUT

IT'S BIG ... IT'S TOUGH ... IT'S *Enduro!*

Yes, it is big and it is tough—it has to be! It's in a modern "torture chamber".

This ENDURO Stainless Steel expansion joint—thirteen feet in diameter—is part of an aircraft laboratory wind tunnel.

Eight of these giants are installed in the header between primary and secondary coolers of altitude exhaust ducts. They handle gases from full scale thermal jet engines, reciprocating engines, turbines, burners and other equipment tested in simulated high altitude conditions. Working pressures range from vacuum to 60 pounds... temperatures as low as –50° F. There's punishment aplenty.

Here's another application in which Republic ENDURO Stainless Steel demonstrates its great strength, toughness, resistance to heat and corrosion... and its fabricating possibilities. Where can you use these qualities? Write Republic for suggestions about applying ENDURO advantages to your own products and processes. No obligation, of course.

REPUBLIC STEEL CORPORATION
Alloy Steel Division • Massillon, Ohio
GENERAL OFFICES • CLEVELAND 1, OHIO
Export Department: Chrysler Bldg., New York 17, N.Y.

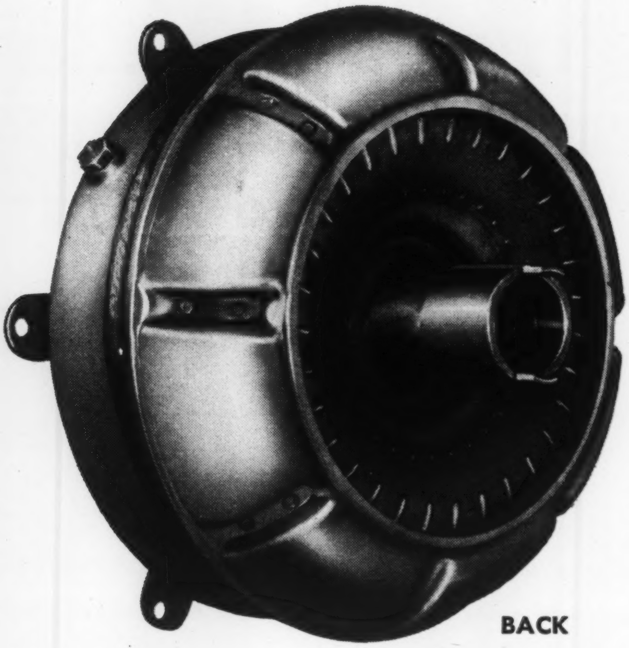
Zallea Brothers, Wilmington, Delaware, use ENDURO Stainless Steel in manufacturing expansion joints of all sizes. Under the Zallea process, there are no circumferential welds in the corrugated section subject to flexing stresses.

Republic
REPUBLIC STEEL ®
ENDURO STAINLESS STEEL

Other Republic Products include Carbon and Alloy Steels—Pipe, Sheets, Tubing, Lockers, Shelving, and Fabricated Steel Building Products

FRONT

Converter is easily adapted to most power units. Made almost entirely from stampings for low-cost production.



BACK

Welded for strength, with leak-proof construction. Designed for direct air-cooling, but oil cooler may be added.

You Equip WELL...at LOW Cost with LONG TORQUE CONVERTERS!

Designed and built to hold *your* costs down in most applications. Long Torque Converters are now in high-volume production for passenger car use. Easily modified for many industrial uses. We are prepared to extend engineering cooperation through to satisfactory installation. Your inquiries are invited.

For Automotive and Industrial Applications:

- Eleven and 12-inch diameters.
- Ninety to 200 lbs.-ft. torque.
- Torque ratios at stall, 2.1 to 1.
- Efficiencies over 90%.

LONG MANUFACTURING DIVISION • BORG-WARNER CORP.
DETROIT, MICH., AND WINDSOR, ONT.

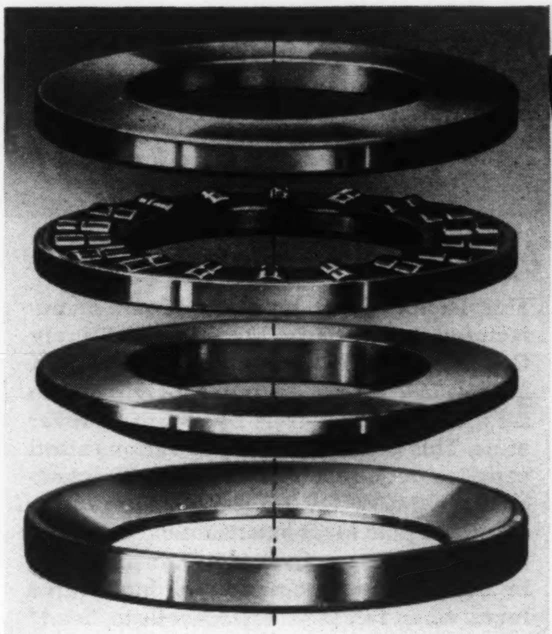
50 Years of Quality Manufacturing for the Automotive Industry

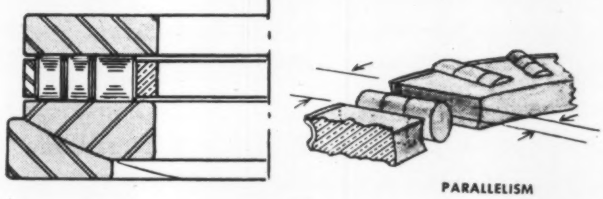
LONG

A PRODUCT OF B-W BORG-WARNER

TORQUE CONVERTERS • CLUTCHES • RADIATORS • OIL COOLERS

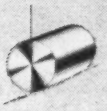
THRUST
RADIAL



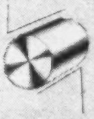


PARALLELISM

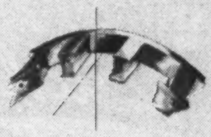
ACCURATE PARALLELISM between the rollers and the matched thrust plates is repeated in the parallelism between the separator slots and the rollers themselves—all adding up to quietness, equalized wear and longer life.



RIGHT ANGLE
Roller Ends, precisely square to avoid end-rub, oscillation and side-shock.



- **RIGHT ANGLE**
Bearing Surfaces with parallelism that results in unwavering right-line rolling.



- **RIGHT ANGLE**
Separator Slots accurately machined to prevent roller skew, slide and uneven wear.

Held to extremely close limits of parallelism, every roller—every race—every thrust plate in a Rollway Bearing is an engineering masterpiece of matched precision and right-angle trueness. As a result, friction losses are low—load capacity and service life high.

Rollway Radial and Thrust Bearings offer the widest selection in types and sizes, available for quick replacement through authorized distributors. Consult your classified phone directory under BEARINGS.

Our engineers are available without cost or obligation to assist you in selecting the correct Rollway Bearing for your needs. Call your nearest Rollway sales office.

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ROLLWAY
BEARINGS

Complete Line of Radial and Thrust Cylindrical Roller Bearings

NOPAK Model "D" Air Cylinder for Right Angle Flat Base Mounting, Rod End.

•

Refer to Sweet's File for Product Designers or write for Bulletin SW-1.

Log-Edger Feed-Rolls lifted by NOPAK Cylinder

controlled by NOPAK 3-Way Air Valve

This Pacific Coast type log edger, manufactured by Albany Machine & Supply Co., Albany, Ore., employs an 8" NOPAK Model "D" Single Acting Air-Cylinder to lift the heavy feed-rolls by means of lever arms. This permits feeding of various sized cants as required. The cylinder is actuated by a 3/4" NOPAK, 3-Way Air Valve, equipped with lever extension-bar enabling the operator to manipulate it from any point in front of the machine. Weighted valve lever, when released, lowers rolls to "feed" position. Heavy springs prevent the feed rolls from dropping full length of cylinder stroke when machine is "empty."

This comparatively simple application may suggest how you can employ NOPAK Valves and Cylinders in your plant or product to actuate and control machine movements.

GALLAND-HENNING NOPAK DIVISION
2752 S. 31st STREET • MILWAUKEE 46, WISCONSIN

NOPAK
VALVES AND CYLINDERS
DESIGNED for AIR and HYDRAULIC SERVICE
Representatives in Principal Cities

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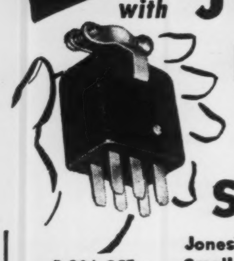
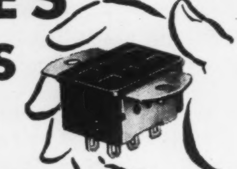
INSURE *Proven Quality* with JONES PLUGS AND SOCKETS





P-306-CCT Plug, Cable Clamp in Cap.

Jones Series 300 illustrated. Small Plugs & Sockets for 1001 Uses. Cap or panel mounting.

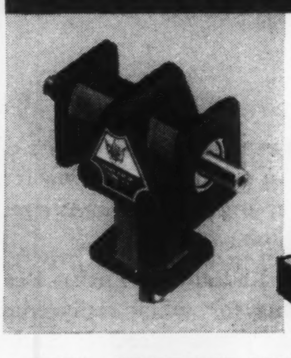
S-306-AB Socket with Angle Brackets.

- Knife-switch socket contacts phosphor bronze, cadmium plated.
- Bar type Plug contacts brass, cadmium plated, with cross section of 5/32" by 3/64".
- Insulation molded bakelite.
- All Plugs and Sockets polarized.
- Metal Caps, with formed fibre linings.
- Made in two to 33 contacts.
- For 45 volts, 5 amperes. Efficient at much higher ratings where circuit characteristics permit.

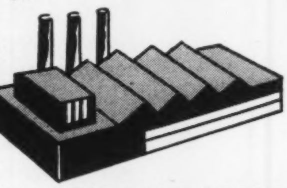
Ask for Jones Catalog No. 18 showing complete line of Electrical Connecting Devices, Plugs, Sockets, Terminal Strips. Write or wire today.

Jones
HOWARD B. JONES DIVISION
CINCH MANUFACTURING CORPORATION
CHICAGO 24, ILLINOIS
SUBSIDIARY OF UNITED-CARR FASTENER CORP.

CROWN MITRE GEAR UNIT



for *INDUSTRIAL APPLICATIONS*



NEW, COMPACT BEVEL GEAR UNIT SOLVES VARIED POWER TRANSMISSION PROBLEMS

- Hardened "ZEROL" gears . . . in precision matched pairs
- Double shielded ball bearings throughout
- Your choice of 4 or 5 mounting faces
- Compactly designed, rigidly constructed for guaranteed industrial service

For detailed information contact your local Industrial Supply Distributor or write direct to

Crown Gear, Inc.
290 West Street Keene, N. H., U. S. A.
Also Manufactured and Sold Through Distributors in Canada by H & R Arms Co., Ltd., Montreal, P. Q.

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THIS TRADEMARK IDENTIFIES MAYLINE QUALITY PRODUCTS

OUTSTANDING DRAFTING EQUIPMENT

Equip your drafting room with Mayline quality furniture. Mayline offers a choice of pedestal type tables and the 4-Post line. Complementary items are: Plan Files and Drawer Units in wood or steel and Auxiliary Drawer Units.

Mayline T-Squares and Straightedges are unexcelled. In seating Mayline has stools and benches.

See your local dealer or write to factory. All inquiries answered promptly.

ENGINEERING MANUFACTURING COMPANY

601 North Commerce Street Sheboygan, Wisconsin

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Herbrand

PRECISION

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...any size or shape up to 200 lbs.

Whatever your requirements in forgings, Herbrand is your most faithful source of supply . . . as it has been for hundreds of industries since 1881 Your inquiries are solicited.

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THE BINGHAM-HERBRAND CORPORATION
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Dependability...

proven on most diesel makes and models

MAKES **DETROIT** *Vernatherm* Engine Thermostats . . .

The *BEST* Choice For Your Needs

If you're concerned with the design of lubricating oil or cooling systems for jet, heavy-duty gasoline or diesel engines it will pay you to specify **DETROIT** Vernatherm Engine Thermostats. For only **DETROIT** Engine Thermostats give you the assurance of dependable, efficient operation performance proven on military and commercial aircraft . . . on ordnance combat vehicles . . . and on most diesel makes and models. So take advantage of this outstanding record—specify **DETROIT** Vernatherm Engine Thermostats, the true standard of the industry for rugged, exacting service! Available as engine cooling thermostats, oil cooler thermostats, shutter thermostats and thermostatic power elements.

All DETROIT Vernatherm Engine Thermostats are . . .

- *Designed to work with either open or closed cooling systems*
- *Not affected by barometric pressure*
- *Built with tight seats for minimum leakage*
- *Not subject to chatter*

ESTABLISHED IN 1877 AS DETROIT LUBRICATOR COMPANY

DETROIT-*Controls* CORP.

DETROIT 8, MICHIGAN Division of American Radiator & Standard Sanitary Corporation
Canadian Representatives in Montreal, Toronto, Winnipeg—Railway & Engineering Specialties, Ltd.

AUTOMATIC CONTROLS for REFRIGERATION
AIR CONDITIONING • DOMESTIC HEATING • AVIATION
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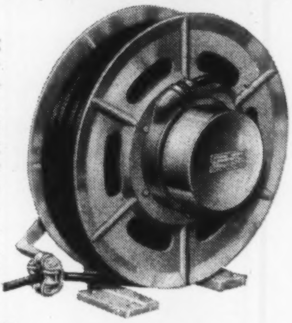
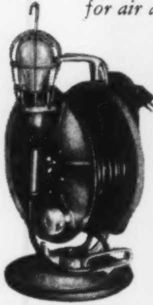
NOW Faster, Easier Cable Handling

Spring-O-Matic



Improved ball-bearing, spring retractable POWEREEL handles up to 150′ multiple conductor cable, sizes up to No. 4. Also for communications cable. Ratchet for stopping reel optional. Adjustable cable guide. Compact, easy to mount. Moisture and dust-proof. Simple, easy cable installation. Cast aluminum reduces weight. *Also available for air and fluid hose.*



PORT-O-REEL

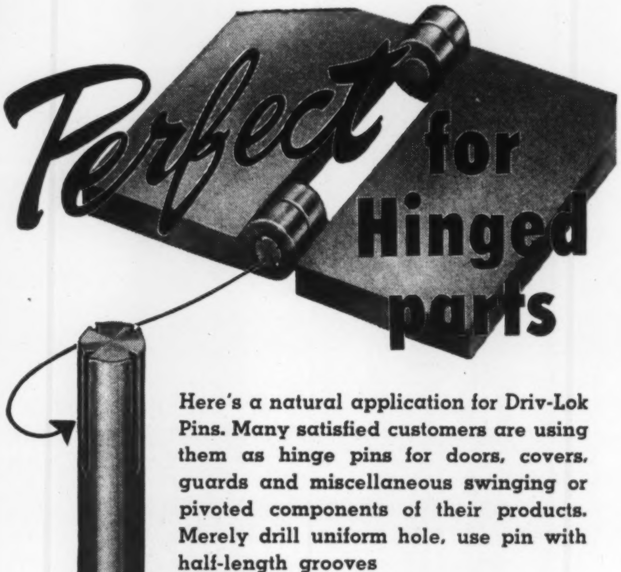
For long cords . . . sizes up to No. 12, 3-conductor. Has dust-tight collector ring, ball-bearing swivel base adjustable brake and lock on reel. Available with or without cord or hand lamp. Wt.—9 lbs. less cable and plugs. Reel 4″ wide, 12″ dia.

COLLECTOR RINGS

Many standard models in stock for immediate shipment. Designing and custom building to meet your special needs. Write or phone for engineering data on stock and special collector rings. Estimates on custom jobs gladly submitted.

We also make POWEREELS for heavy-duty cables, and specially engineered Torque-Motor Reels. If you have a special Reel or Collector Ring problem write or phone today.

INDUSTRIAL ELECTRICAL WORKS
MD-6 1509 Chicago St. — Phone ATlantic-4600 — Omaha, Nebr.



Here's a natural application for Driv-Lok Pins. Many satisfied customers are using them as hinge pins for doors, covers, guards and miscellaneous swinging or pivoted components of their products. Merely drill uniform hole, use pin with half-length grooves which lock in one part and permit free rotation of other part.

Each application suggests countless others. There are types and sizes of DRIV-LOK Pins to fit them all. Write for Catalog.

DRIV-LOK PIN COMPANY
715 Chauncey Street, Sycamore, Illinois

QUALITY ENGINEERED GRC GOSHEN 'O' RINGS

Goshen Grommets

A Goshen specialty is grommet production—in a great range of sizes, shapes and compounds . . . few or many . . . from stock molds or custom-engineered. For prompt action, consult Goshen on your next grommet, rubber part or O-Ring problem.

Write for Grommet Catalog

Goshen Rubber Company INC.
MOLDED • DIE CUT • LATHE CUT RUBBER SPECIALTIES SINCE 1916
1763 S. Tenth St. Goshen, Indiana

dependable
...accurate

Abart SPEED REDUCERS

Even on your most difficult applications, you can depend on Abart Speed Reducers to deliver efficient, economical power transmission and accurate reduction ratios. These compact units are precision built for exacting performance and long, trouble-free service.

Choose from over 75 sizes and types. Worm, spur, and combination gear. Ratios up to 10,000 to 1. Horsepower ratings from 1/50 to 168. All Abart Reducers are oil tight and dust free.

Send for illustrated pocket size Catalog containing full engineering data on Abart Speed Reducers and Gearmotors.

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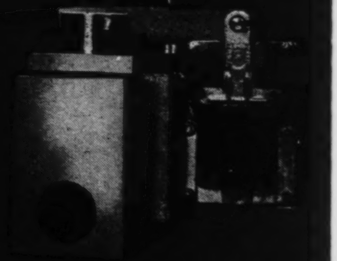
Mfrs. of Gears, Speed Reducers and Gearmotors

High Pressure SOLENOID VALVES . . .

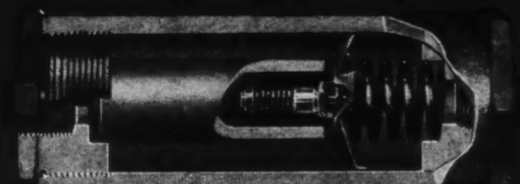


[illegible] for handling of any non-corrosive fluids. Compact construction eliminates leakage. Tempera- [illegible] oil and moisture resistant. Unit can be mounted in any position. Available in 110-220 A.C.

ADJUSTABLE FLOW REGULATORS

for cylinder speed control over a 50% range, are built for pressures to 2000 psi. Model 320 shown meets the requirements for cylinder speed adjustment yet maintains constant speed regardless of work or pressure fluctuations. There are types for Machine Tools—Earth Moving, Material Handling and Farm Equipment—Packaging Machinery—Steel and Paper Mills—Refineries—Printing Presses.

MICRONIC LINE FILTERS

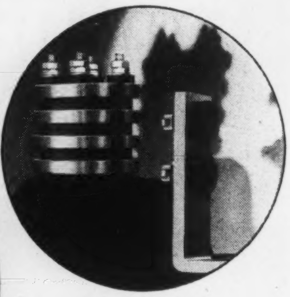


[illegible] for air, oil, water and [illegible] 40 Microns [illegible] valves and cylinders. [illegible]

Write for our engineering cooperation or illustrated circular F

WATERMAN ENGINEERING Company
725 CUSTER AVENUE
EVANSTON, ILLINOIS

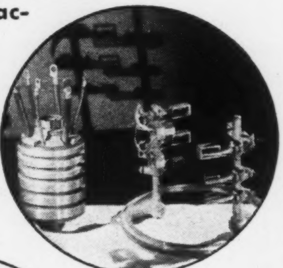
Collector Rings

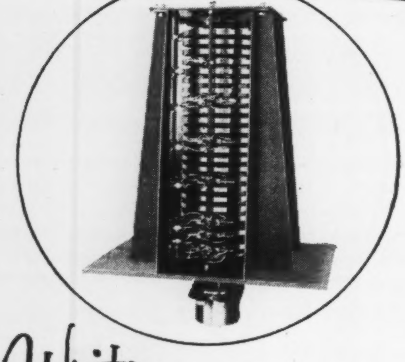


Wesche Collector Rings are available in many standard designs and sizes. More typically, we are called upon to design and build custom rings for a specific application.

Collector rings serve to complete electric circuits between stationary and revolving parts such as heated rolls, revolving platforms or cranes and rotating machine parts. Wesche Rings are bronze, insulated from each other with phenolic or fibre. Required number of terminals extend from one or both ends. Two to more than 40 rings may be assembled into a unit rating from fractional to more than 200 amperes. Up to 48" diameter.

Silver plating, split rings and many other special optional features to order.





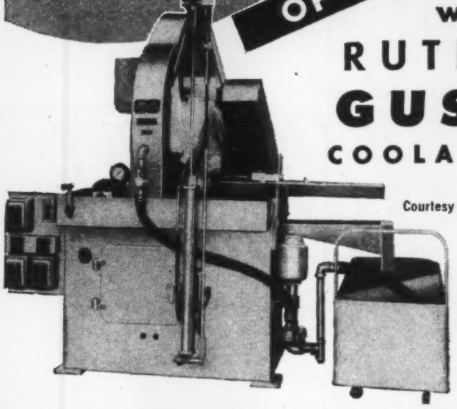
Write

for catalog containing data sheet for easy ordering.

THE B. A. WESCHE ELECTRIC CO. (Welco)
1620 VINE STREET • CINCINNATI 10, OHIO

CUT COSTS OF METAL CUTTING

with a
RUTHMAN
GUSHER
COOLANT PUMP

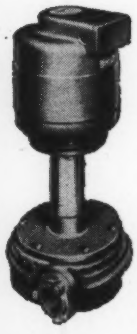


Courtesy American Chain & Cable Co.

Illustrated is a Campbell 406 Wet Abrasive Cutting Machine equipped with a Ruthman Gusher Coolant Pump.

Costs are down when you use a Gusher, for Gusher Coolant Pumps assure you efficient operation and long trouble-free life.

You get instantaneous coolant flow, as much or as little as you need. The heavy duty prelubricated ball bearings, dynamically balanced rotating shaft with no metal-to-metal contact within the impeller housing gives you a long trouble-free life for your gusher. Write us today.



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With the background of decades of experience, its makers have pioneered in modern improvements to maintain Imperial as the finest tracing cloth made.

Crosscurving

may answer your Power Spring problem!

For your products requiring flat-type power springs . . . you should look into the opportunity to improve performance and give longer operating life with use of Sandsteel "crosscurved" mainsprings. Because of their concave-convex curvature they deliver DUAL POWER . . . smoother, more even release of energy and longer run.

FREE brochure on request — "Sandsteel Springs for Your Products."

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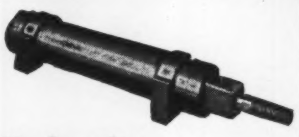
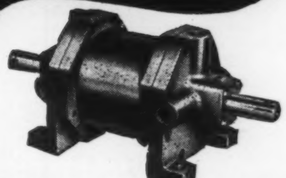
SANDVIK STEEL, INC.
145 HUDSON STREET, NEW YORK 13, N. Y.

GET THESE FEATURES IN ALL YOUR FUTURE *CYLINDERS*





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- ★ Automatic rod packing requires no take-up. Seals under pressure
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➔ *FREE* Additional Data

covering additional construction and performance features are included in this catalog. Write for your copy today. Ask for bulletin 350.

Hydro-Line

HYDRO-LINE MFG. CO.
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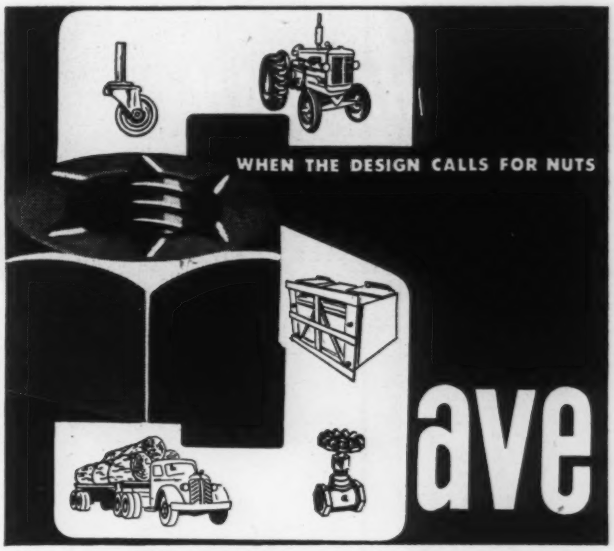
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BECAUSE THEY'RE SO SIMPLE

Whatever your product is, if Economy is a factor, specify Gripco Lock Nuts. You'll save money because Gripco Lock Nuts *Cost Less.* The reason: simple design; no inserts, outside devices or gadgets that add to the cost.

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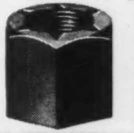
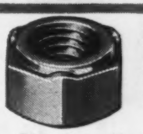


GRIPCO COUNTERSINK LOCKING WELD NUTS

Gripco exclusive countersink feature increases distance between threads and welding projections, so that any weld spatter cools and solidifies before it contacts threads.

GRIPCO PILOT-PROJECTION LOCKING WELD NUTS



Circular pilot accurately positions nut over bolt hole, for instant resistance welding. No jigs required. Another time and money-saver.

Write for samples, mentioning types and sizes of nuts you use.

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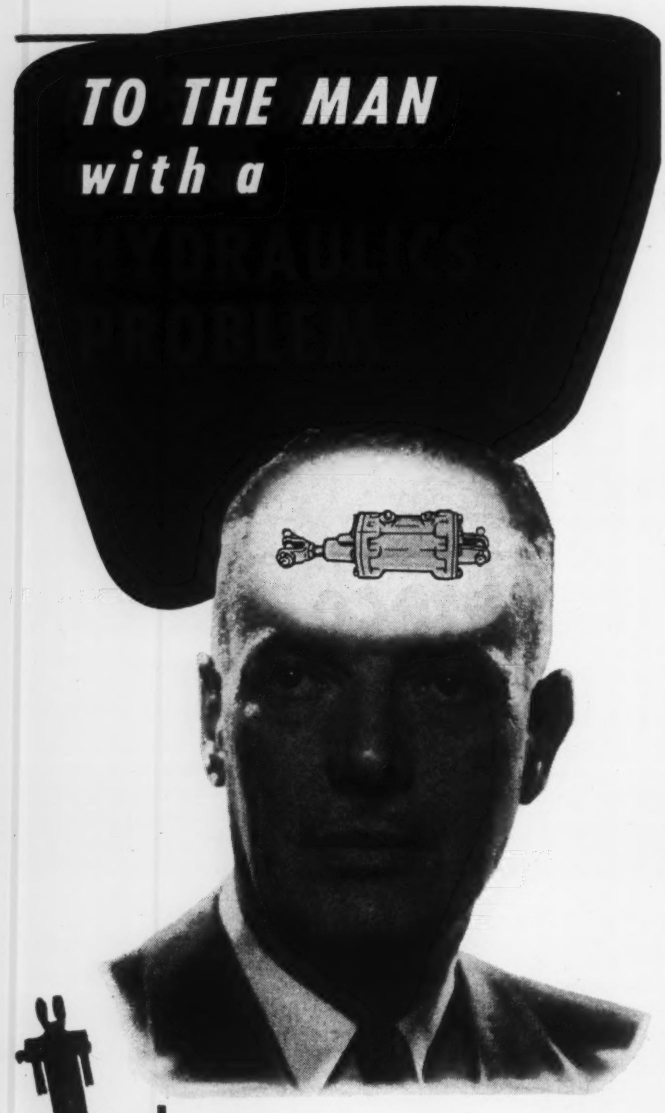

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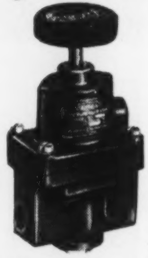

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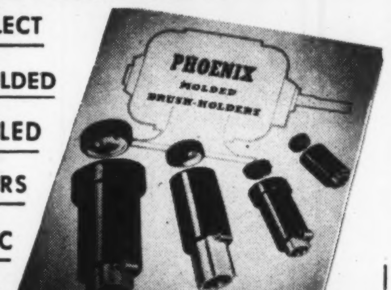

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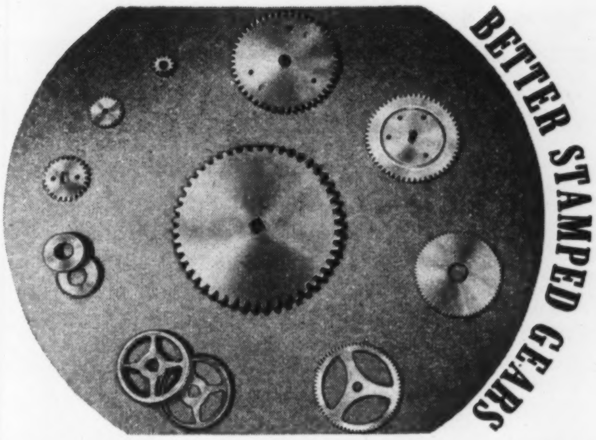

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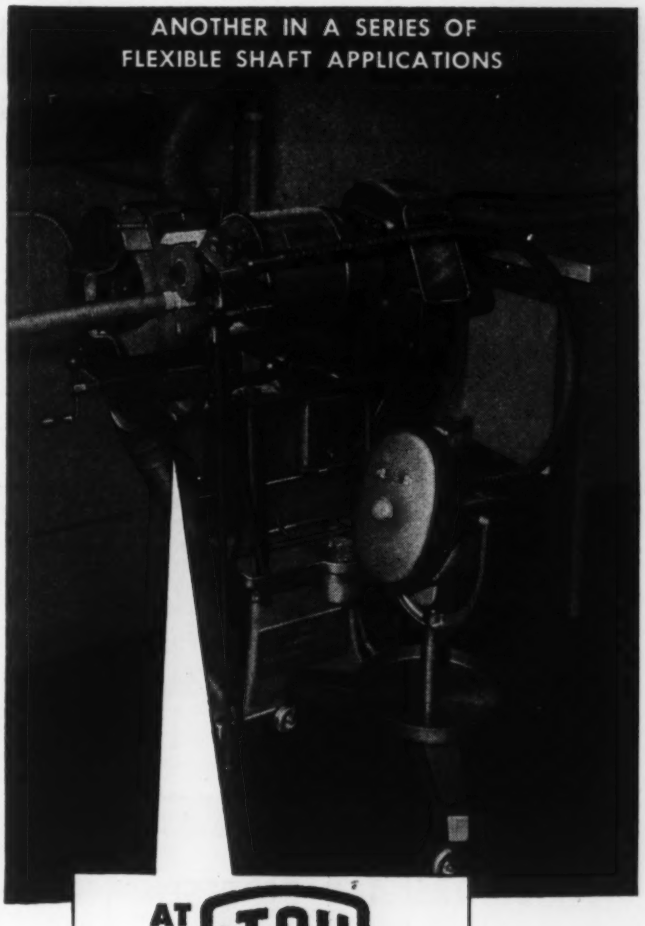

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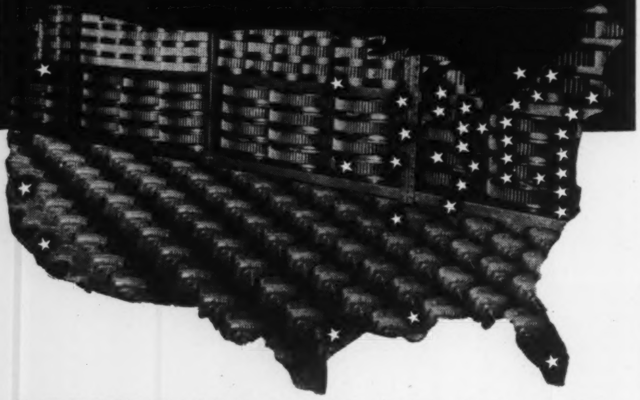

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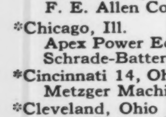

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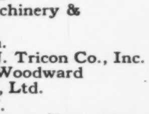

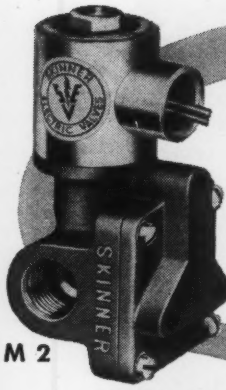

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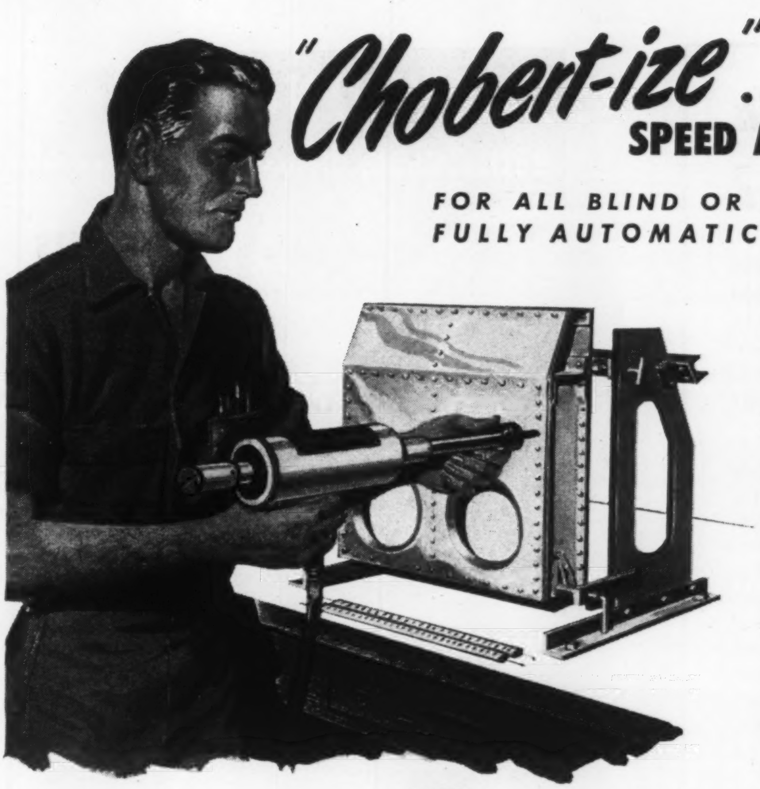"Chobert-ize" ... FOR INCREASED RIVETING SPEED AND PRODUCTION ECONOMIES!

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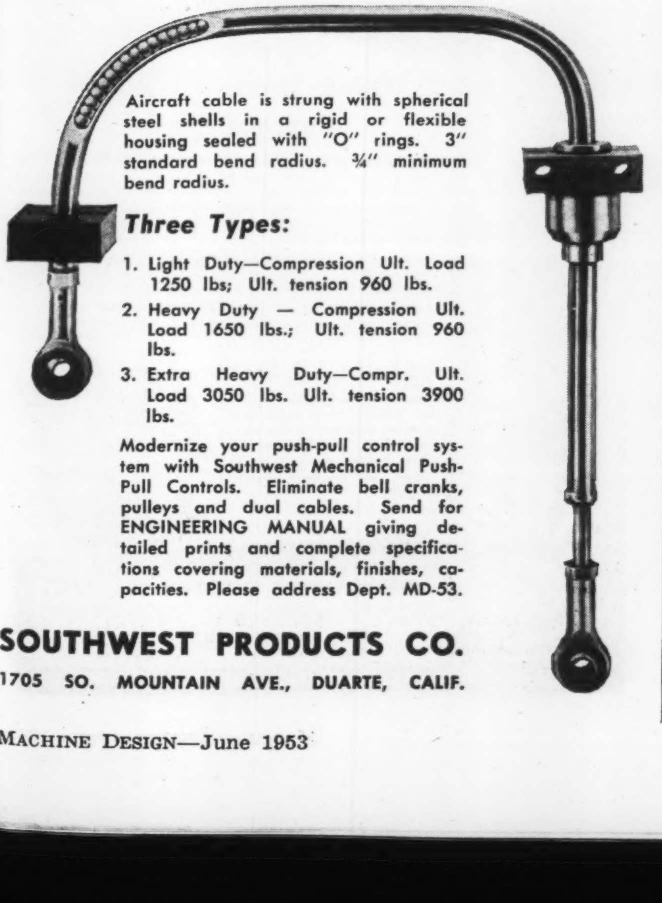PUSH-PULL CONTROLS

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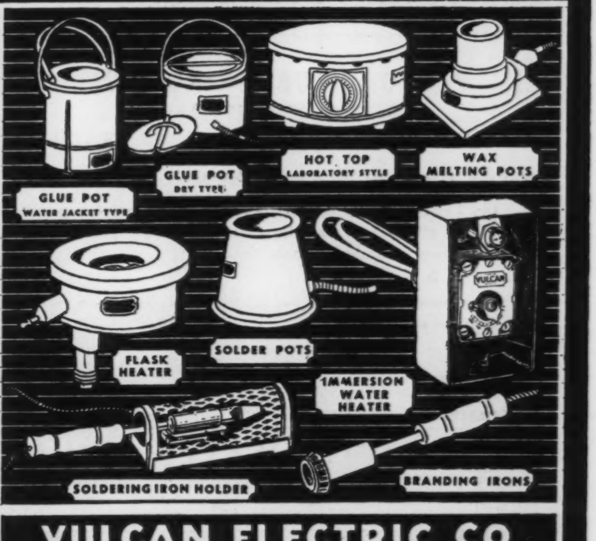

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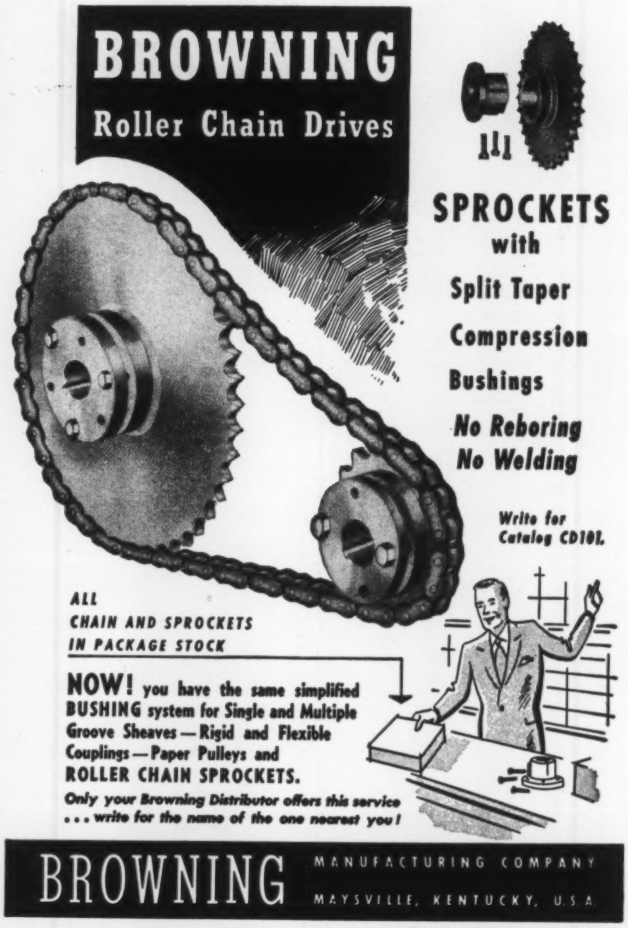

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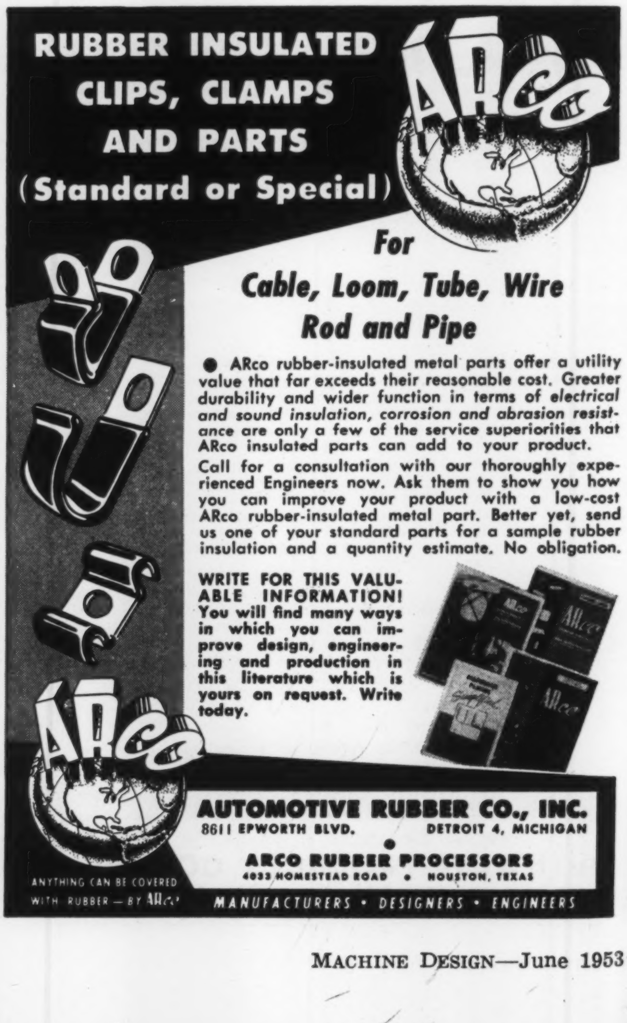

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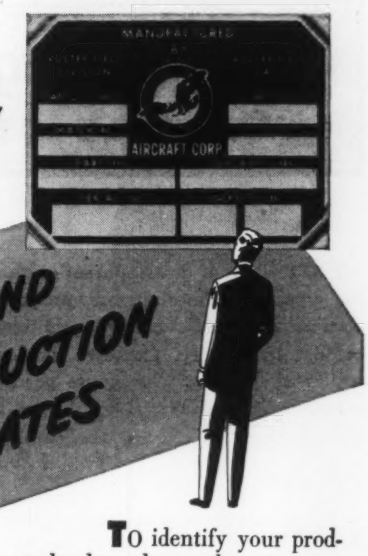

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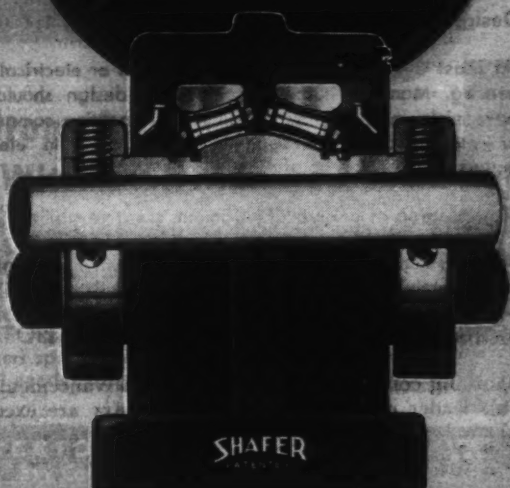

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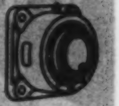

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Cartridge Units

Duplex Units

Take-Up Units

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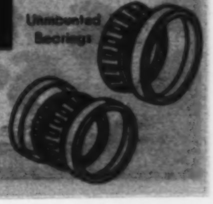

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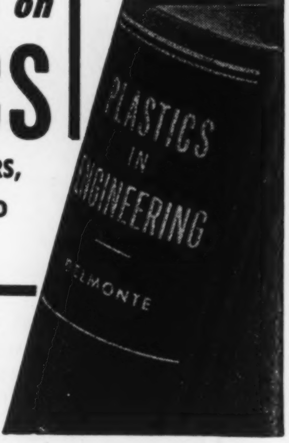

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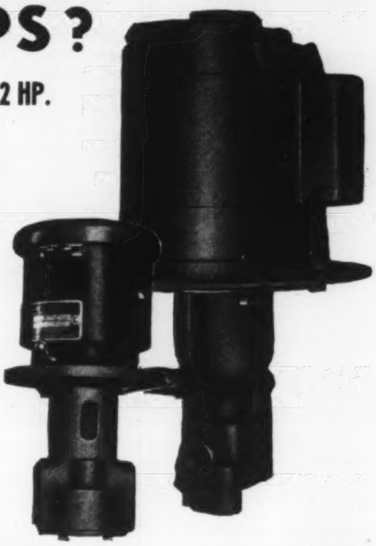

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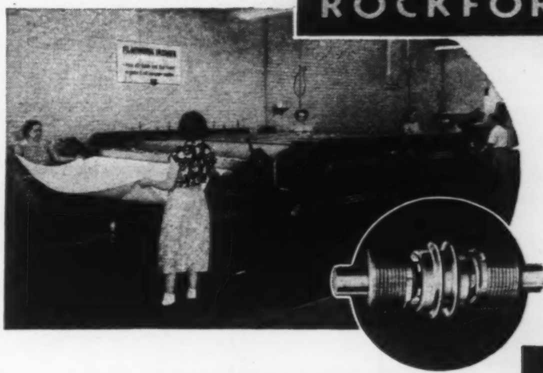

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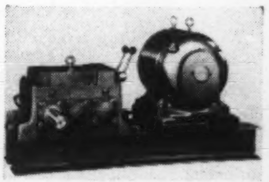

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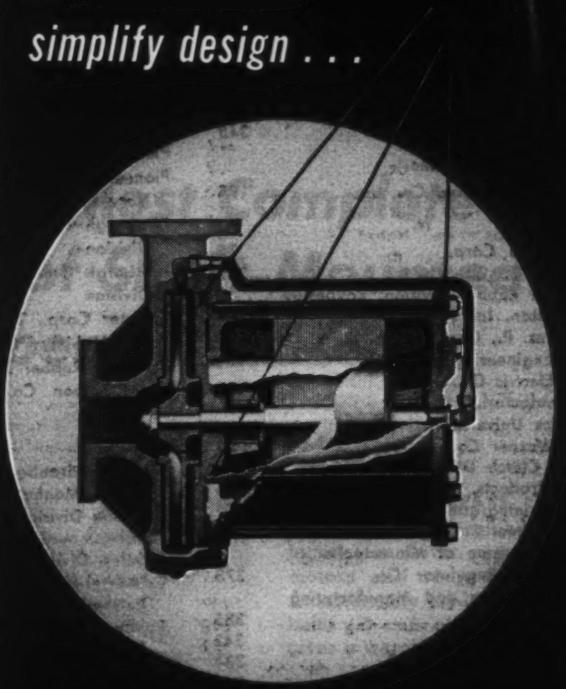

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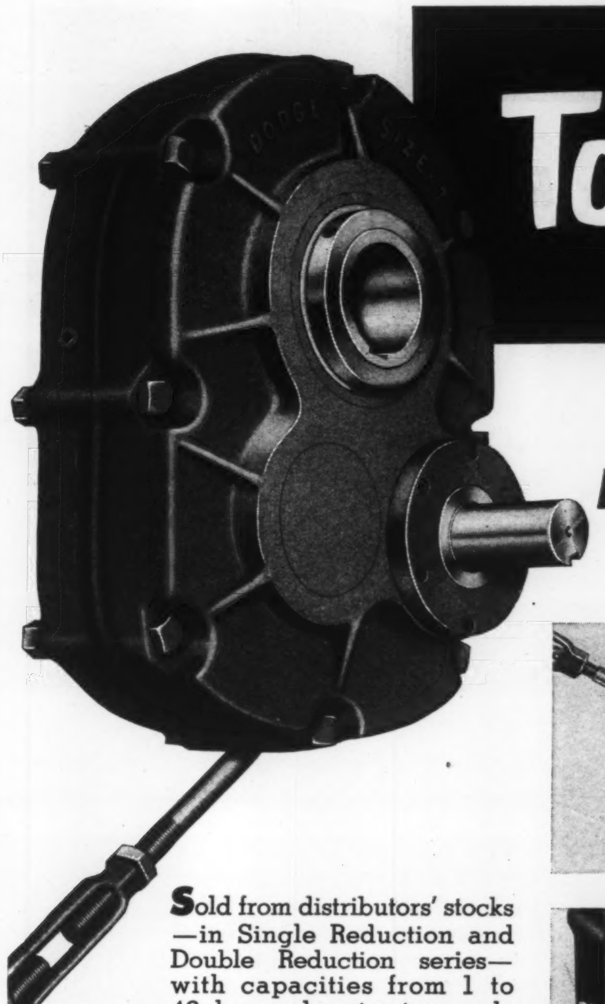

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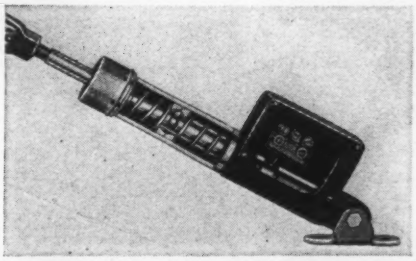

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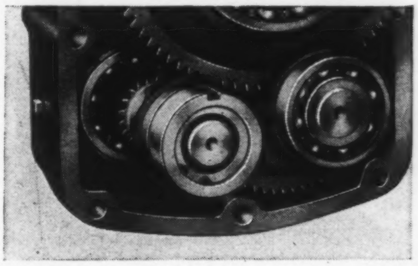

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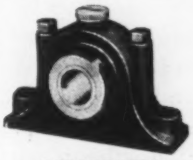

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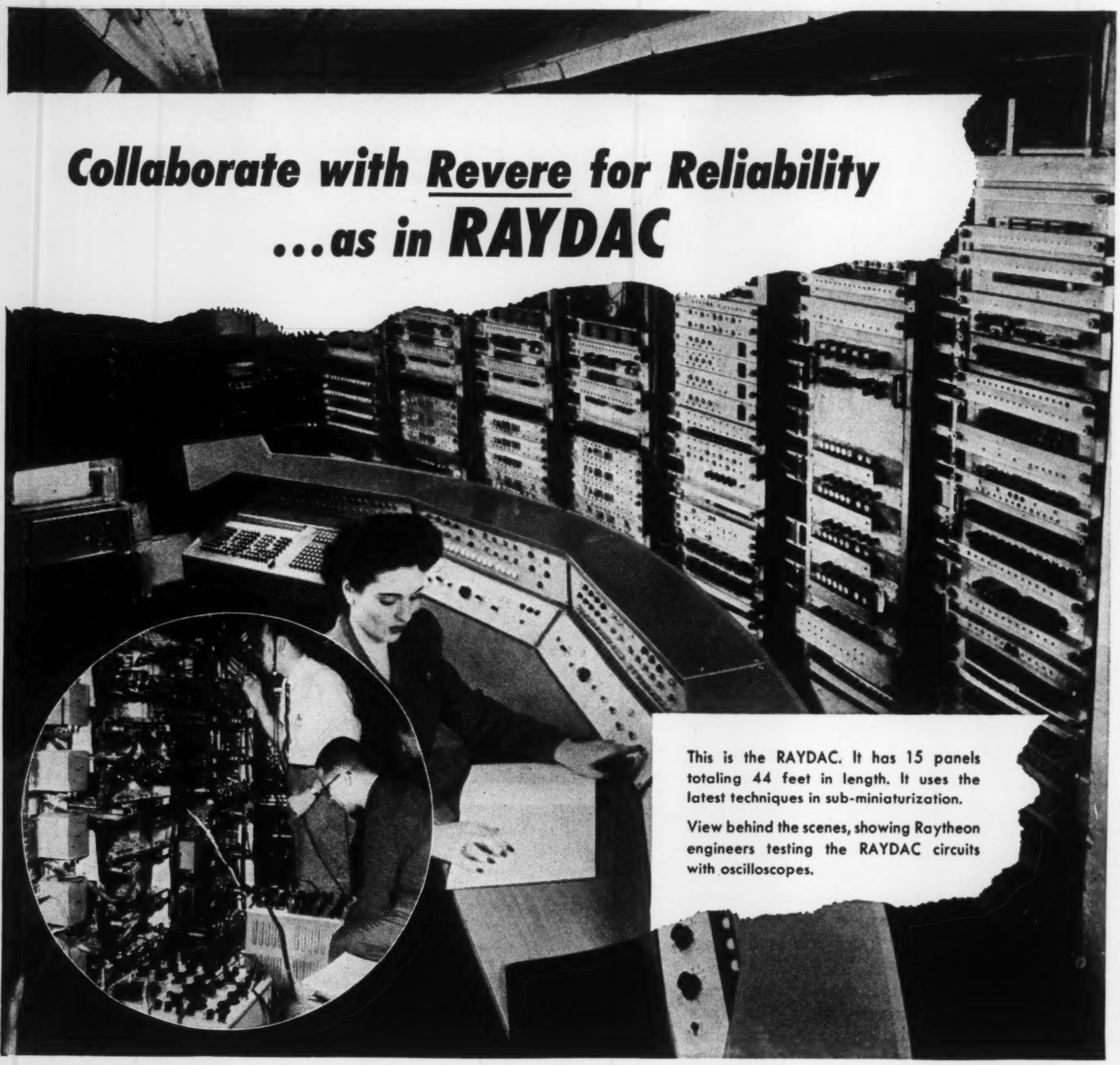

This is the RAYDAC. It has 15 panels totaling 44 feet in length. It uses the latest techniques in sub-miniaturization.

View behind the scenes, showing Raytheon engineers testing the RAYDAC circuits with oscilloscopes.

RAYDAC means Raytheon Digital Automatic Computer, developed by the Raytheon Manufacturing Company, Waltham, Mass., for the Navy's Bureau of Aeronautics. It is an "intelligence center" to help analyze the behavior of missiles during test flights. Its importance is indicated by the fact that in a matter of minutes it can perform the calculations involved in analyzing a single missile flight, a task that would take a team of mathematicians from 20 to 30 days. The Raydac thus speeds up tremendously the development and testing of such missiles. It contains enough tubes and germanium diodes made by Raytheon, for more than 1,000 home radio sets.

In such a complicated electronic computer reliability is essential. This is achieved through design, the choice of the best materials and components, and meticulous manufacture. Revere during the past 10 years has collaborated closely with Raytheon, working out proper specifications for materials, as for example, OFHC copper. Raytheon engineers and production men have visited Revere laboratories at New Bedford, Mass., and Rome, N. Y., and many Revere specialists have studied methods and processes in the Raytheon plants and laboratories. These hand-in-glove contacts, many of them highly confidential, have proved their value.

The same kind of collaboration is open to you, and will be especially useful and time-saving if begun as soon as you have a new project on your boards. To obtain it, simply get in touch with the nearest Revere Sales Office. See your telephone book or write direct.

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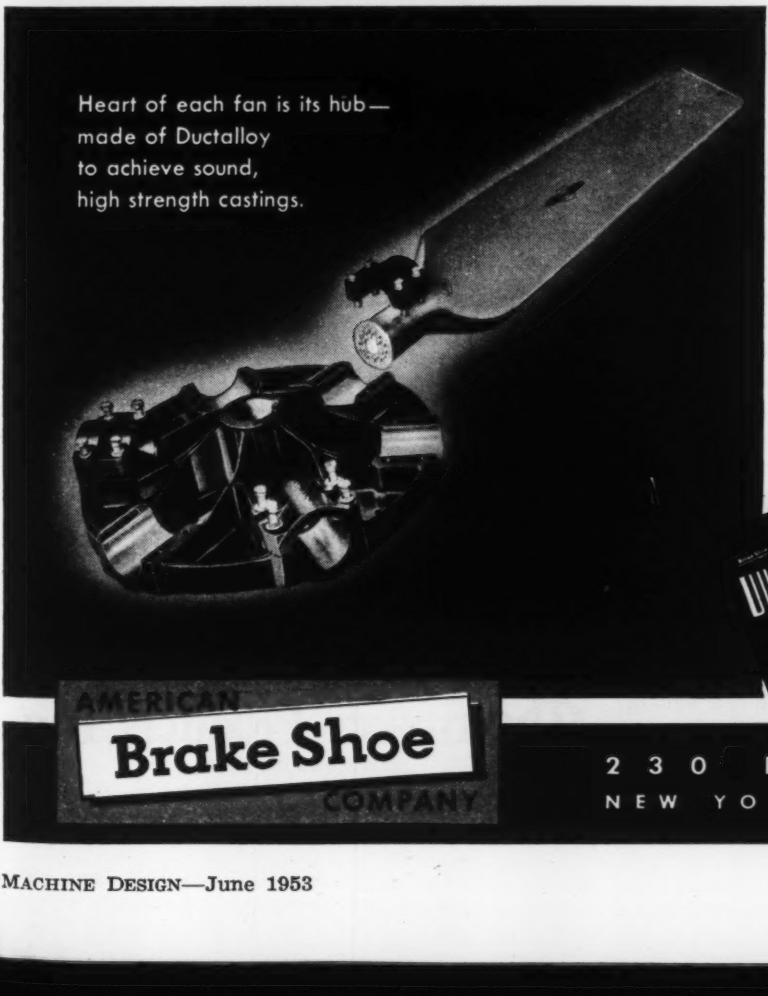
Strong, Sound Hubs

Aeromaster axial flow fans range up to 24 ft. in diameter and deliver as much as 1,000,000 cfm.



Heart of each fan is its hub—made of Ductalloy to achieve sound, high strength castings.

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High performance fans made by the Aeromaster Fan Department of Koppers Company, used in cooling towers near diesel engines and compressors, must withstand considerable applied vibration in addition to normal operating loads. For this reason cast steel was originally specified to provide the necessary hub strength; but machining costs were excessive, surfaces were poor, and too many castings were "lost" when machining revealed hidden defects. A switch to malleable iron only aggravated the problem of casting soundness. The answer was Ductalloy 60—Brake Shoe's easily machined high strength ductile cast iron.

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Ductalloy 60 is a ferritic iron having 60,000 psi minimum tensile strength, 40,000 psi minimum yield strength and 10% minimum total elongation, all guaranteed. Use of this material has virtually eliminated the high scrap loss formerly encountered when defects were uncovered during machining of castings made in either steel or malleable iron.

your problem — Ductalloy may solve your problem if it involves economical production of complex metal shapes that are difficult to cast in steel, expensive to forge or lacking strength in gray iron. Brake Shoe's experience, research laboratory and experimental foundry are available to help you best utilize Ductalloy's unusual combination of characteristics. Write for this new technical bulletin today.

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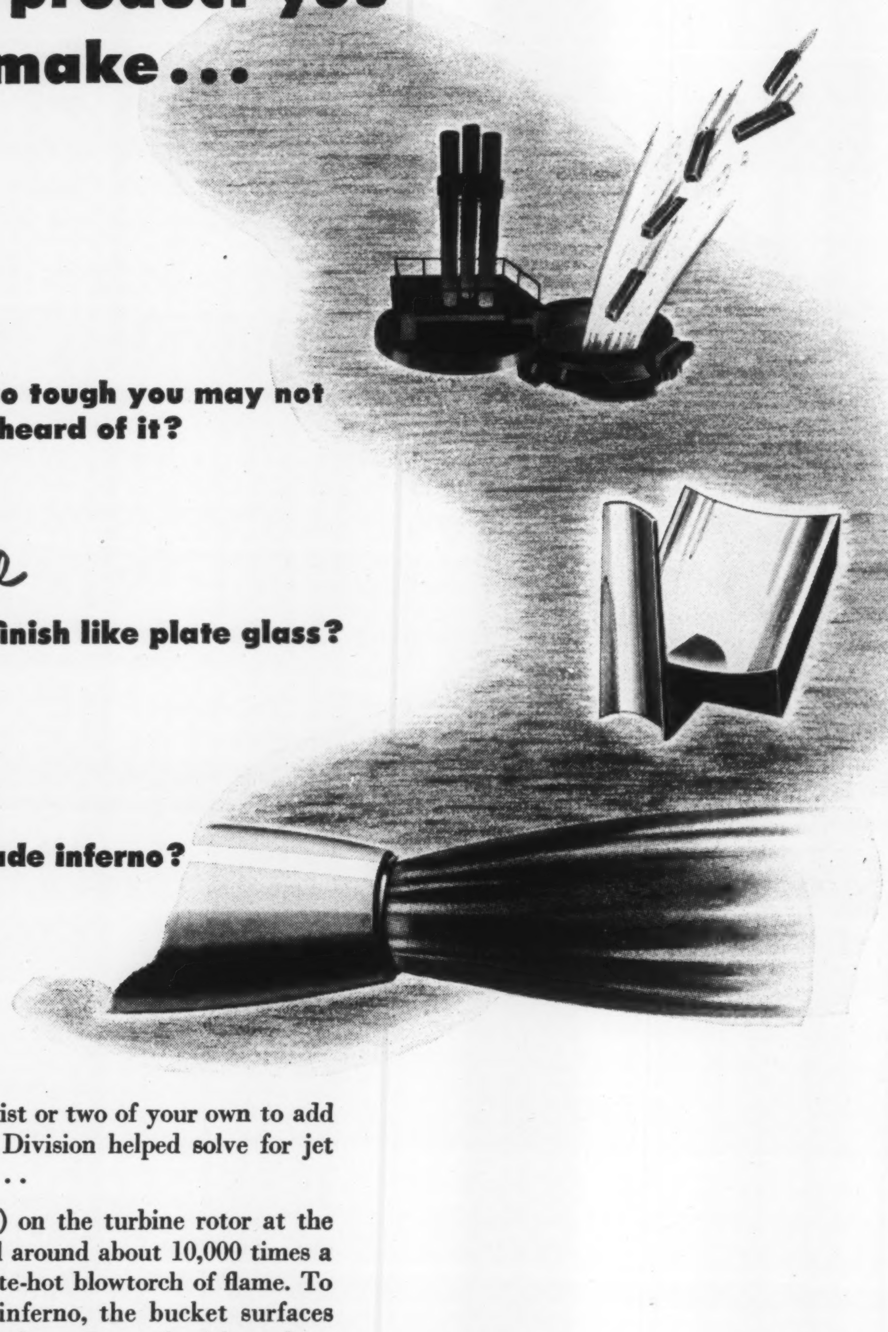

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an alloy so tough you may not yet have heard of it?

.... *require*

a forged finish like plate glass?

.... *face*

a man-made inferno?

You may even have a twist or two of your own to add to the problem the Jet Division helped solve for jet aircraft engine builders . . .

The "buckets" (paddles) on the turbine rotor at the rear of a jet engine whirl around about 10,000 times a minute, pulsed by a white-hot blowtorch of flame. To withstand this roaring inferno, the bucket surfaces and curves must be forged even smoother than glass. They must be made of an alloy tougher than the toughest steel. They must "take" this red-hot ride for hours without stretching out, or "creeping", from centrifugal force and heat.

The Jet Division makes more buckets for America's engine builders than any other manufacturer. We forge super-strength alloys into finished parts so smooth and accurate that they need no costly, lengthy finish-machining or polishing.

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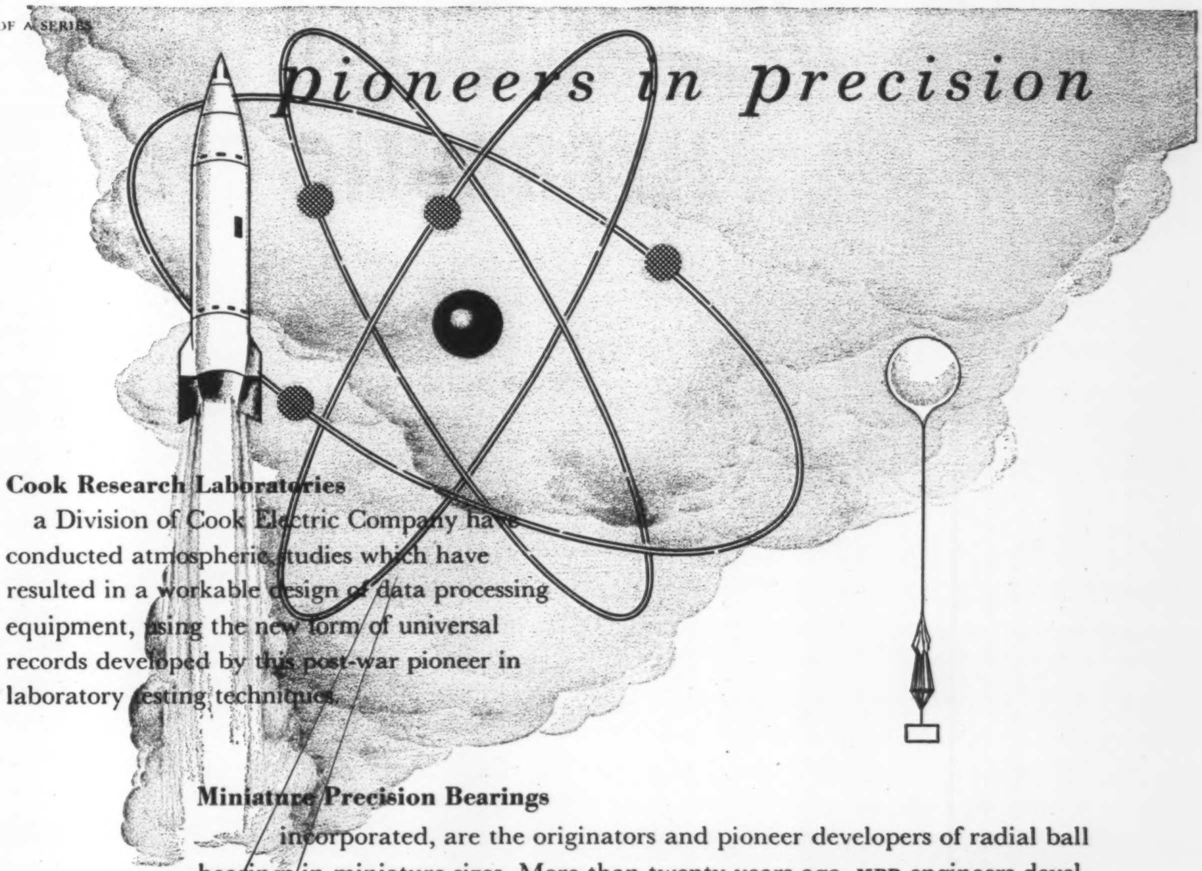
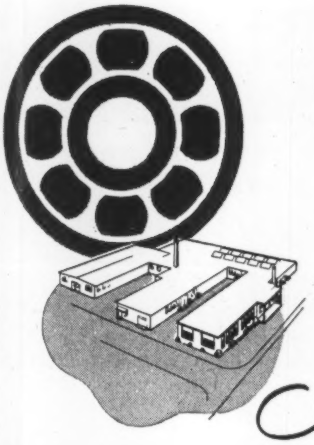


Cook Research Laboratories
a Division of Cook Electric Company have conducted atmospheric studies which have resulted in a workable design of data processing equipment, using the new form of universal records developed by this post-war pioneer in laboratory testing techniques.

Miniature Precision Bearings
incorporated, are the originators and pioneer developers of radial ball bearings in miniature sizes. More than twenty years ago, **MPB** engineers developed the first miniature radial ball bearings with ground races. From an original group of five ball bearings, **MPB** has developed a comprehensive line of more than 130 types and sizes, many of which now form the basis for international standardization.

Thousands of contemporary problems involving space, weight, and friction are being solved by the extensive variety of **MPB** ball bearings. They are fully ground, lapped, and/or honed to ABEC 5 tolerances or better. **MPB** ball bearings are torque tested, ultrasonicly cleaned, supplied in specific tolerances and classified within the tolerances for prompt assembly and maximum service. **MPB** ball bearings are normally supplied in 10 series, from 1/10″ to 5/16″ o.d., of high carbon chrome bearing steel. Most are supplied in stainless steel, some in beryllium copper, and all are assembled with best quality balls.

The wealth of engineering knowledge gained through participation in more than a million applications is available. Call on us for assistance, also request new catalog 53 and supplementary data sheets MD6.



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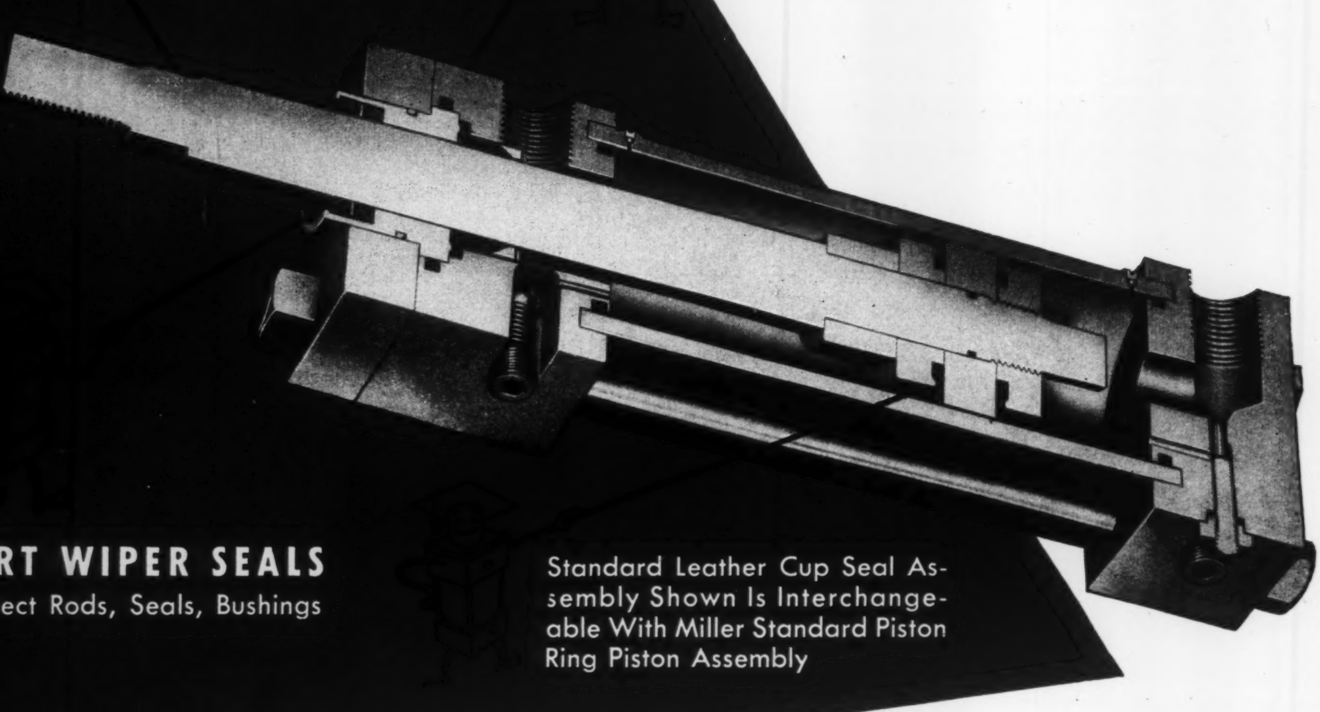

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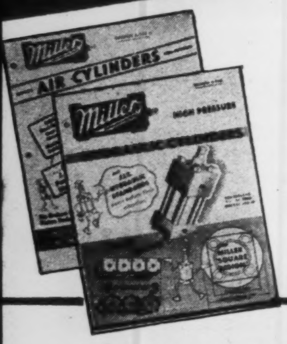
Protect Rods, Seals, Bushings

Standard Leather Cup Seal Assembly Shown Is Interchangeable With Miller Standard Piston Ring Piston Assembly



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Extra toughness for your heaviest shock loadings, extra wearability to slash your maintenance costs, and extra fatigue life to give you longer uninterrupted service! These extra values in every length of Atlas Roller Chain are pre-tested daily on the Atlas Metallograph, for proven performance year after year on your power transmission drives.

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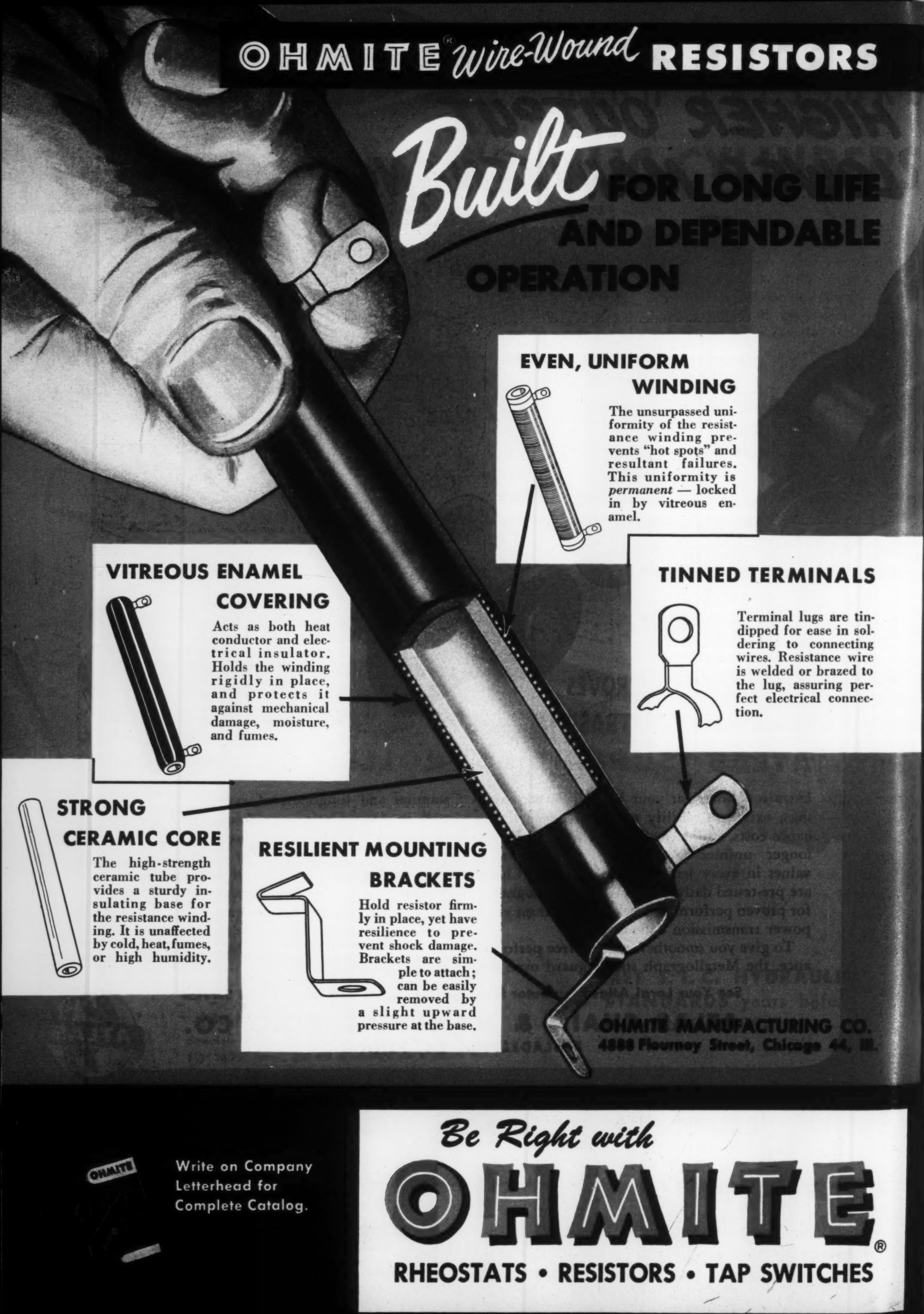

OHMITE® *Wire-Wound* RESISTORS

Built FOR LONG LIFE AND DEPENDABLE OPERATION

EVEN, UNIFORM WINDING

The unsurpassed uniformity of the resistance winding prevents "hot spots" and resultant failures. This uniformity is *permanent* — locked in by vitreous enamel.

VITREOUS ENAMEL COVERING

Acts as both heat conductor and electrical insulator. Holds the winding rigidly in place, and protects it against mechanical damage, moisture, and fumes.

TINNED TERMINALS

Terminal lugs are tin-dipped for ease in soldering to connecting wires. Resistance wire is welded or brazed to the lug, assuring perfect electrical connection.

STRONG CERAMIC CORE

The high-strength ceramic tube provides a sturdy insulating base for the resistance winding. It is unaffected by cold, heat, fumes, or high humidity.

RESILIENT MOUNTING BRACKETS

Hold resistor firmly in place, yet have resilience to prevent shock damage. Brackets are simple to attach; can be easily removed by a slight upward pressure at the base.

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RHEOSTATS • RESISTORS • TAP SWITCHES

SIMPLICITY in hydraulic pump design is important for these reasons:

The Pesco hydraulic pump is a gear design—the simplest of all hydraulic pumps. There are actually only three moving parts in the pump proper. Fewer moving parts mean—

. . . less chance of pump malfunction
. . . less maintenance
. . . less cost for overhaul
. . . less weight
. . . less noise

plus the EFFICIENCY of "Pressure Loading" which makes possible:

"*Pressure Loading*" is Pesco's exclusive development that *automatically* holds end clearance of gears to a thin film of oil, thereby maintaining the volumetric efficiency throughout the long service life of the pump.

. . . volumetric efficiencies up to 97% over a wide range of temperatures

plus STATISTICAL QUALITY CONTROL which assures:

. . . uniform high quality and performance of each pump
. . . a longer, trouble-free service life

Simplicity of design, *efficiency* of "*Pressure Loading*" and *statistical quality control* in all phases of manufacture, are three important reasons why Pesco pumps are standard equipment on military and commercial aircraft and on many automotive and industrial products. Write today regarding your hydraulic pump requirements.

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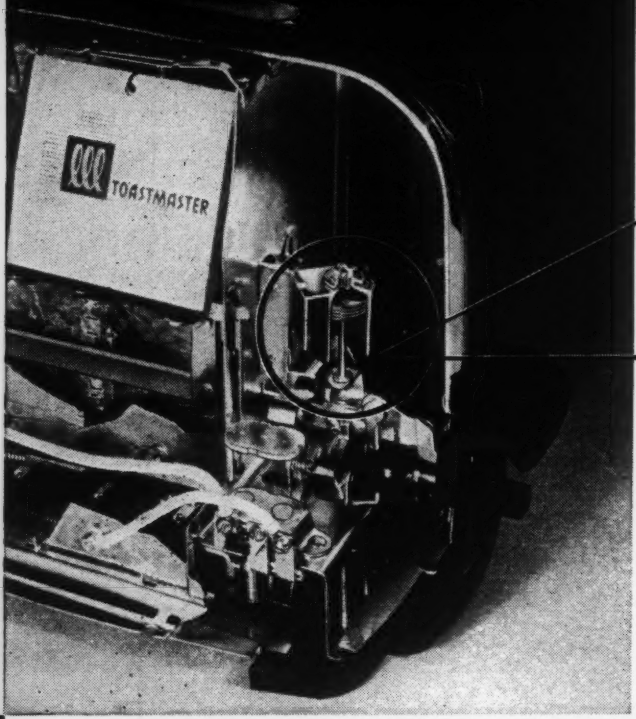

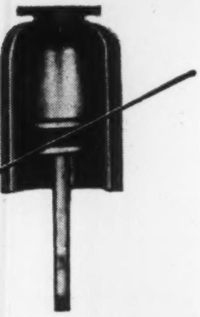

Restrictions on brass forced engineers in the Toastmaster Products Division of McGraw Electric Company to find substitute materials for a pneumatic damping device on the toast ejector mechanism. They had been using a cylinder, machined from solid ¾ inch brass rod, and a precision ground brass piston with a connecting rod on a swivel joint. The cylinder head was fitted with a spring and ball check valve. Tolerances on this complicated assembly had to be held within 2 mils to give satisfactory performance for at least 100,000 cycles at 350° F.

In pneumatic dampers SILASTIC* simplifies design

...saves critical materials

Many substitute materials and designs were tried with disappointing results before one of our technical representatives dropped in with samples of Silastic. Using this heat-stable, rubbery silicone product, Toastmaster's research and development engineers perfected a very simple and durable damper. It consists of an inexpensive drawn steel cylinder, a 1-piece connecting rod, and a flat ring-shaped Silastic piston mounted loosely between two metal cup washers with a simple air leak past the shoulder of the piston.

Tolerances on the new damper are large; the cylinder can be out of round; 86 pounds of mild steel displace 199 pounds of brass per 1000 toasters. *And the new device works better than the more expensive brass assembly.* Such performance proves the usefulness of Silastic as a new engineering material. It retains its rubbery properties and its good dielectric properties at temperatures ranging from below —70 to above 500° F. It is highly water repellent; shows excellent resistance to weathering and to a variety of hot oils and chemicals.

For more information on the properties or fabricators of Silastic mail this coupon today or phone our nearest branch office.

Dow Corning Corporation, Dept. P-6, Midland, Mich.
Please send me:
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☐ List of Silastic Fabricators.
☐ "What's A Silicone?", your new 32-page booklet on silicone products and applications.

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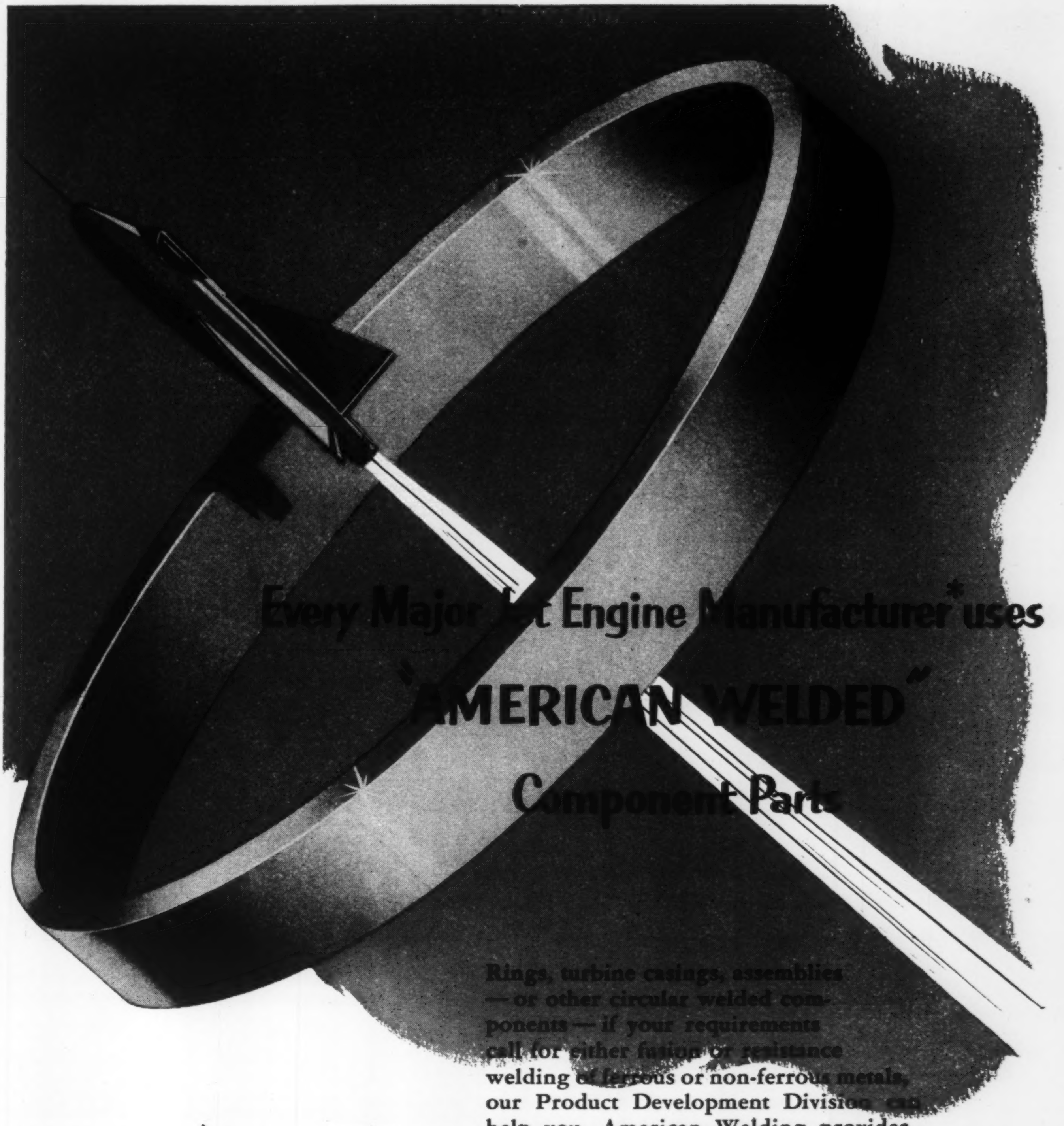

Every Major Jet Engine Manufacturer* uses "AMERICAN WELDED" Component Parts

Rings, turbine casings, assemblies — or other circular welded components — if your requirements call for either fusion or resistance welding of ferrous or non-ferrous metals, our Product Development Division can help you. American Welding provides designing, engineering, metallurgical and machining facilities. Give our local representative a call — or write direct — we will be glad to study your problem.

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THE AMERICAN WELDING & MANUFACTURING COMPANY

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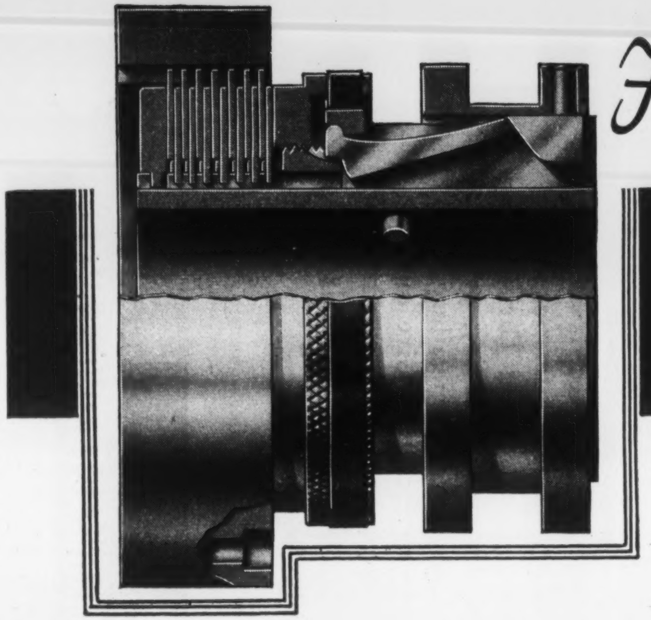

For **MACHINE TOOLS... MACHINERY... PRODUCT DESIGN...** *Specify*

MAXITORQ *floating discs* **CLUTCH**

We hope you haven't minded turning this magazine around, but it was the only proper way to include the picture at the bottom. It clearly shows all parts of a single Maxitorq Clutch...and how easy it is to adjust it, take it apart, and assemble it...manually.

Each and every part contributes to smooth, positive, trouble-free clutch operation. The Separator Springs between each pair of inner discs keep them "floating" in neutral...preventing drag, abrasion, and heat. A Locking Plate locks all discs against the tension of the Separator Springs. The Adjusting Ring provides the means for obtaining the desired shifting pressure.

These are some of the reasons why we counted 69 machines, exhibited at the last Machine Tool Show, that were equipped with Maxitorq floating disc clutches. Send for our 50th Anniversary Catalog...and see how Maxitorq answers your problems for dependable power transmission.

There are 2 basic types of Maxitorq clutches . . . Single and Double. Above is a cut-away view of the single type . . . the double is shown at right. Each is available in 8 capacities (wet or dry) from ¼ to 15 h.p. @ 100 r.p.m. And from 13 to 788 max. working torque ft. lbs. Pulley type, Ring type, or Cut-off Coupling Driving Cups are also available.

The Maxitorq automatic overload release clutch (up to 5 h.p.) is extremely useful for protection of machine and product against accidental overload in high speed production. Special bulletin on request.

Send for Catalog No. MD-6

THE CARLYLE JOHNSON MACHINE CO.
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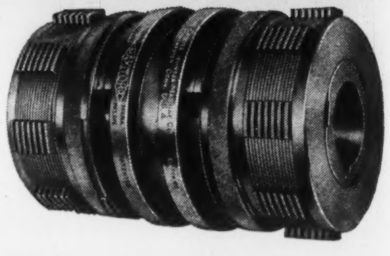
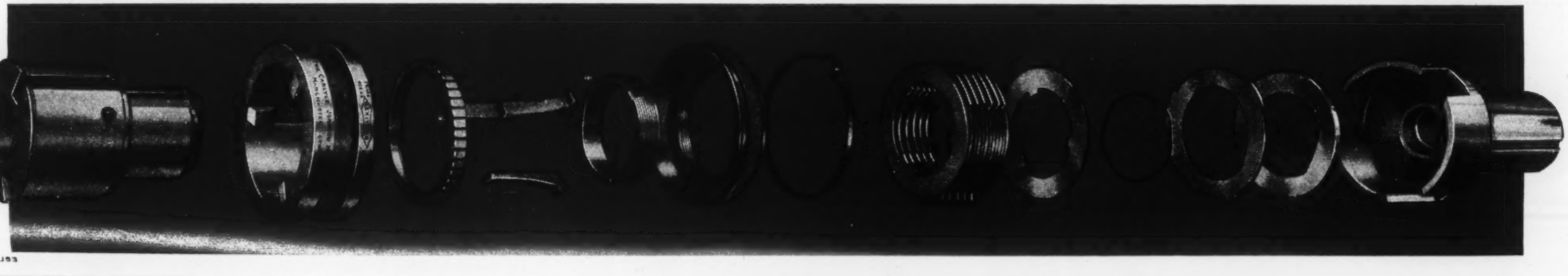


Compact, rugged construction and precise machining . . . flat, true surfaces on engaging faces of the discs . . . provide not only the exacting accuracy required in important industrial machines, but also long, profitable service life.

Our engineers will give you personal assistance for correct selection of the right clutch and installation for your specific requirement.

ALL ASSEMBLY, DISASSEMBLY AND ADJUSTMENTS ARE MANUAL. CLUTCHES SHIPPED ASSEMBLED ON THE BODY.



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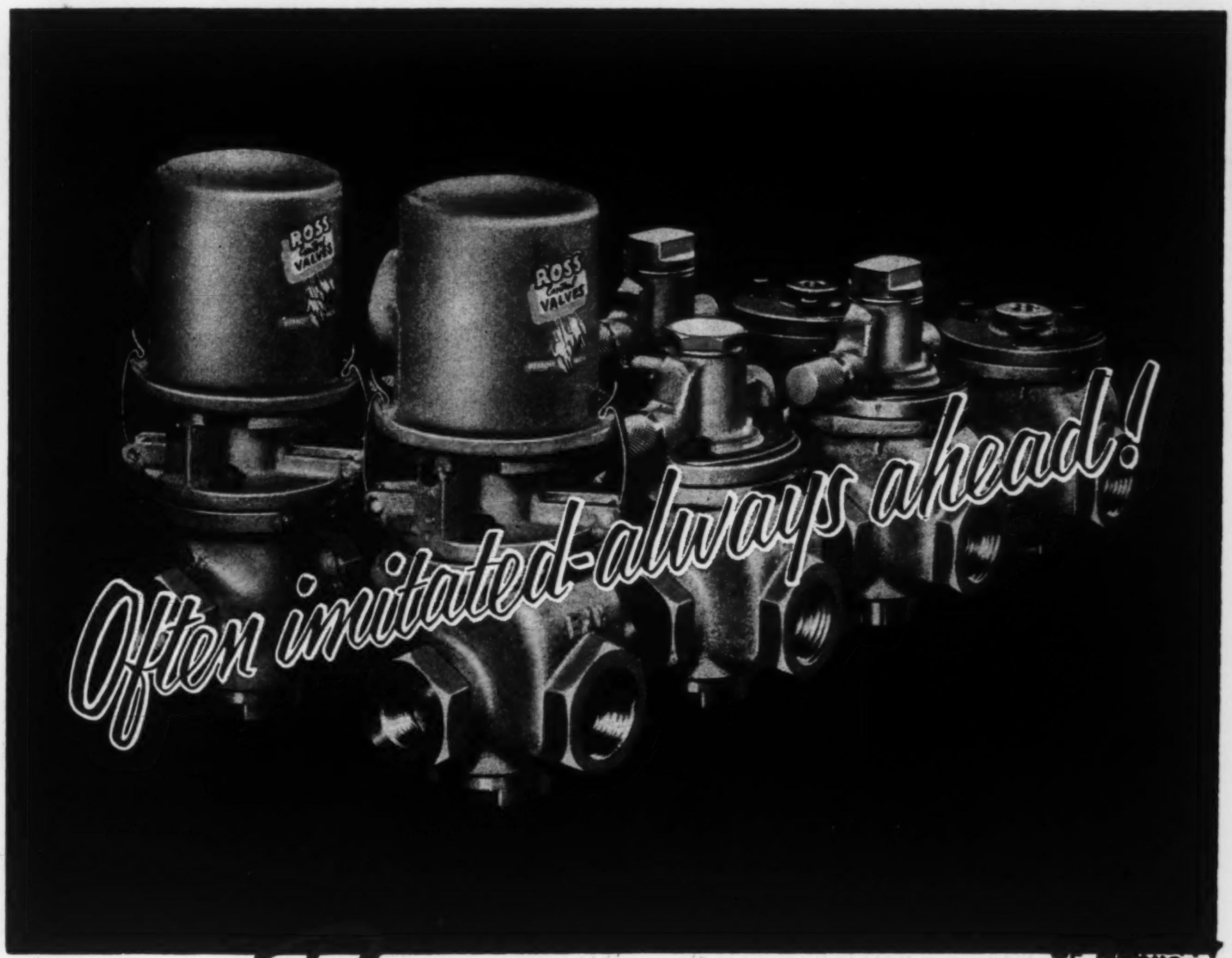

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- ***Dependable***—10 to 20 million maintenance-free cycles, and many more tens of millions of life-cycles, are not uncommon.
- ***Speedy***—split second operation; oversized exhaust.
- ***Low current consumption for solenoid models***—inrush of 1.2 amps @ 110/60.
- ***Positive seal***—poppet construction; Hycar seats.
- ***Easy maintenance***—only a few moving parts; can be disassembled without breaking line connections — solenoids readily accessible.
- ***Many modifications***—vacuum, air, and liquid service; various pressures; available for AC or DC solenoids or air actuation with or without sequence timing; interchangeable heads.

Write for full information on the Ross In-line Series

Ross OPERATING VALVE COMPANY

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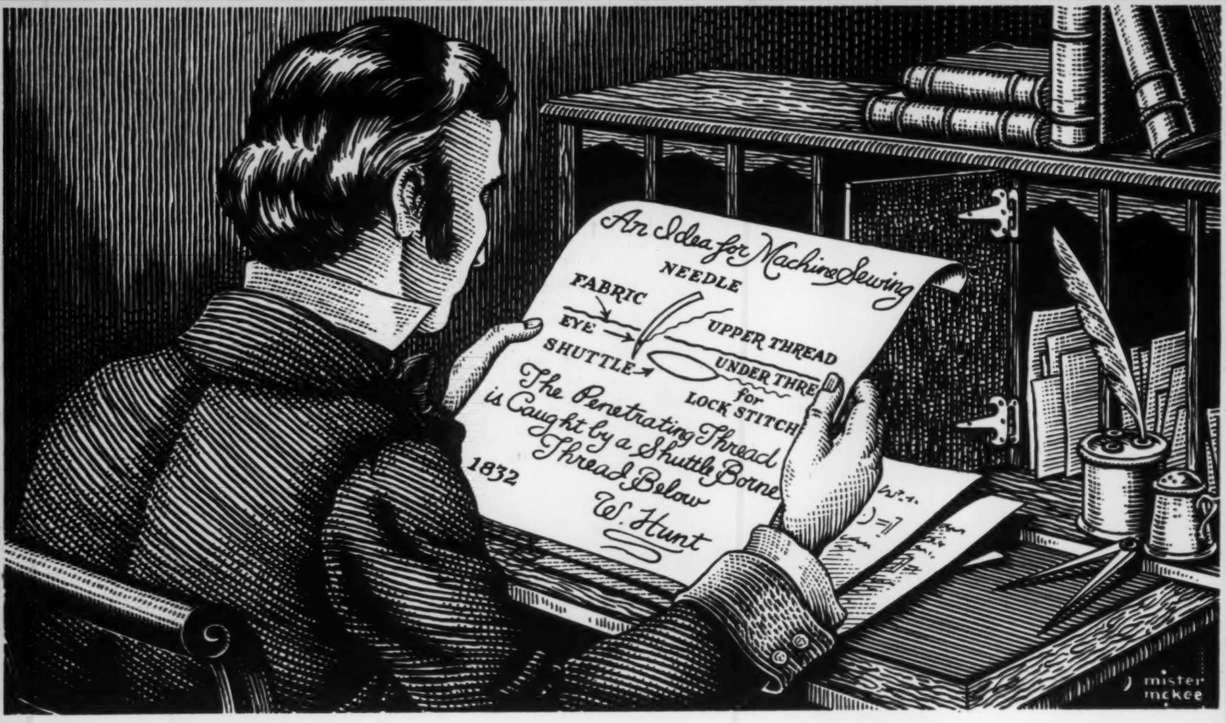

Two Million Dollars for a Needle

Sewing is probably as old as mankind, but not until the year 1832 did the hole move to the point of the needle, so that machine sewing became possible. Walter Hunt of New York City had this great idea, combining with it the shuttle-carried lock-stitching thread on the underside of the fabric.

Elias Howe usually gets credit for inventing the sewing machine, but actually he worked out the idea twelve years after Hunt. Howe, you see, had the good sense to patent the idea. It brought him over two million dollars.

It's great to have an idea. It's much more wonderful to make it work. That's where we come in.

Often difficult and unusual problems are involved in operating mechanisms that depend on *pliable parts*. These must be *composed* and *designed* for continuous dependable service under a wide variety of environment and operating conditions, often in the presence of deteriorative materials or conditions.

For such critical parts, perhaps the most versatile and reliable material ever developed is SIRVENE. This is an oil-resistant elastomer (loosely called synthetic rubber) *compounded in formula* as will best meet the specific need.

SIRVENE engineers are constantly working on pliable part problems, in scores of fields. They are constantly developing new SIRVENE compounds. And when design and compositions are determined, C/R quantity production takes over, operating at laboratory-quality level.

Let SIRVENE engineers work with you from the inception of your idea for a new product. They can short-cut your work, protect you in advance against disappointment.

"Engineering with Sirvene" will be sent with our compliments if you request it. It belongs in your files.

Sirvene products include diaphragms, boots, gaskets, oil seals, washers, packings and similar molded parts.

CHICAGO RAWHIDE MANUFACTURING CO.

1304 Elston Avenue SIRVENE DIVISION Chicago 22, Illinois

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SIRVENE

SCIENTIFICALLY COMPOUNDED ELASTOMERS

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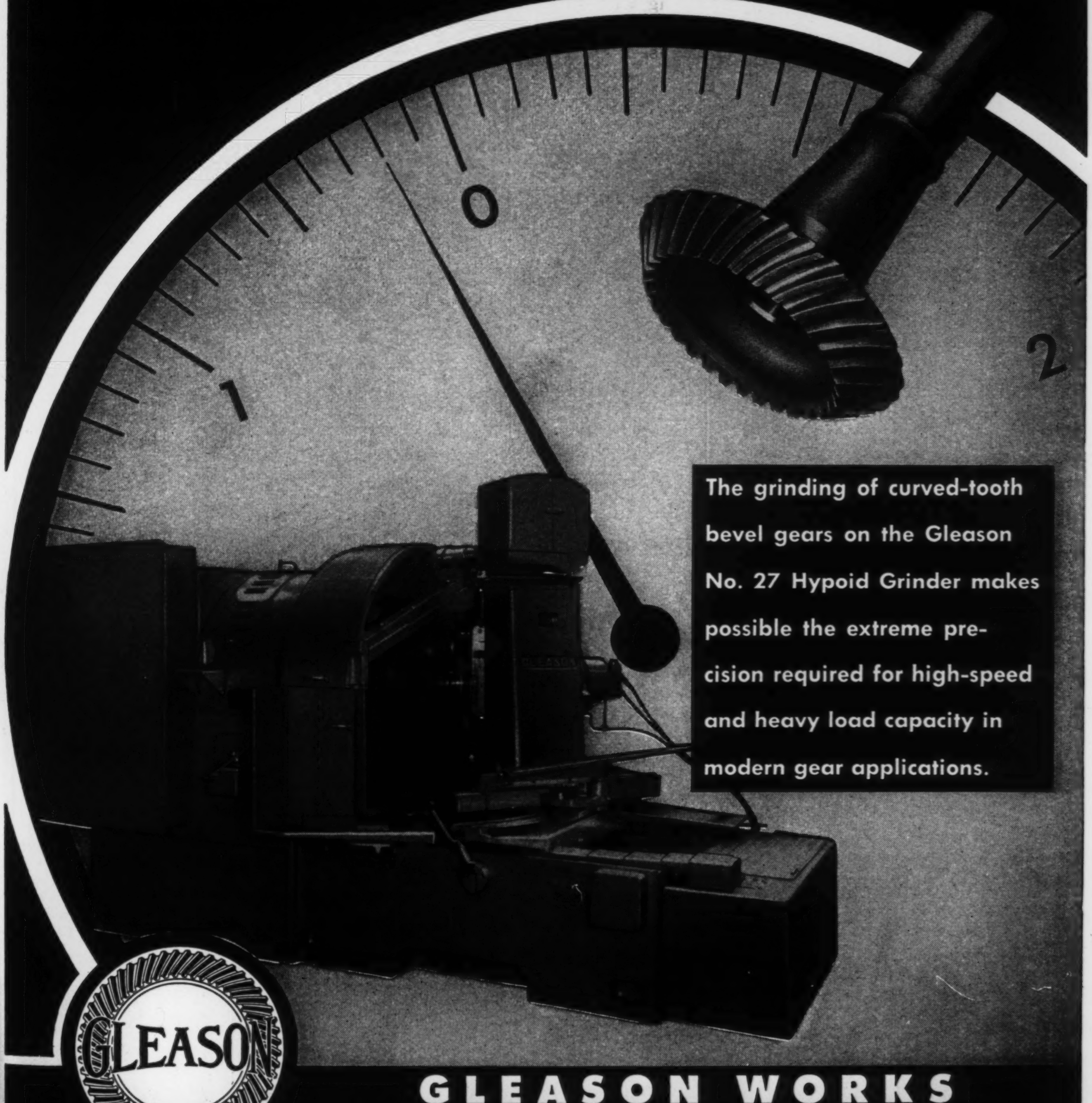

The grinding of curved-tooth bevel gears on the Gleason No. 27 Hypoid Grinder makes possible the extreme precision required for high-speed and heavy load capacity in modern gear applications.

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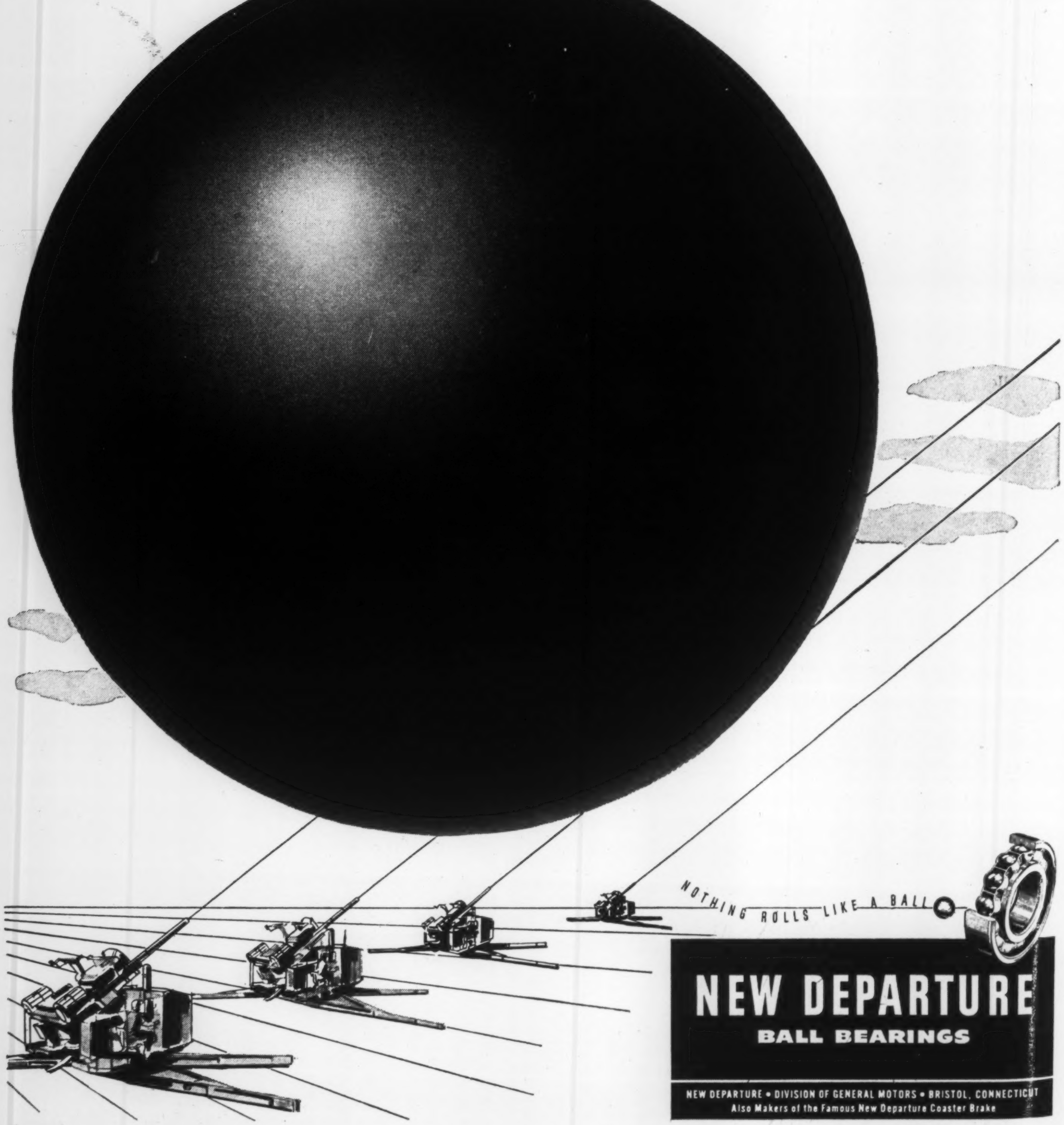
SKYSWEEPER -ACCURATE TO THE ND DEGREE

This wonder weapon can detect an approaching enemy aircraft 15 miles (90 seconds) away and blast it out of the sky. The *Skysweeper* automatically gauges the speed and course of the oncoming target and fires proximity-fused shells to bring down the plane.

Precision-made New Departure ball bearings help give the *Skysweeper* its uncanny ability to detect and destroy. These instrument bearings are marvels of accuracy themselves. All component parts must pass countless inspections . . . meet the highest manufacturing standards in the industry.

In all applications, specify bearings that fight friction as efficiently as the *Skysweeper* fights enemy jets . . . specify New Departures!


NOTHING ROLLS LIKE A BALL

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BALL BEARINGS

NEW DEPARTURE • DIVISION OF GENERAL MOTORS • BRISTOL, CONNECTICUT
Also Makers of the Famous New Departure Coaster Brake

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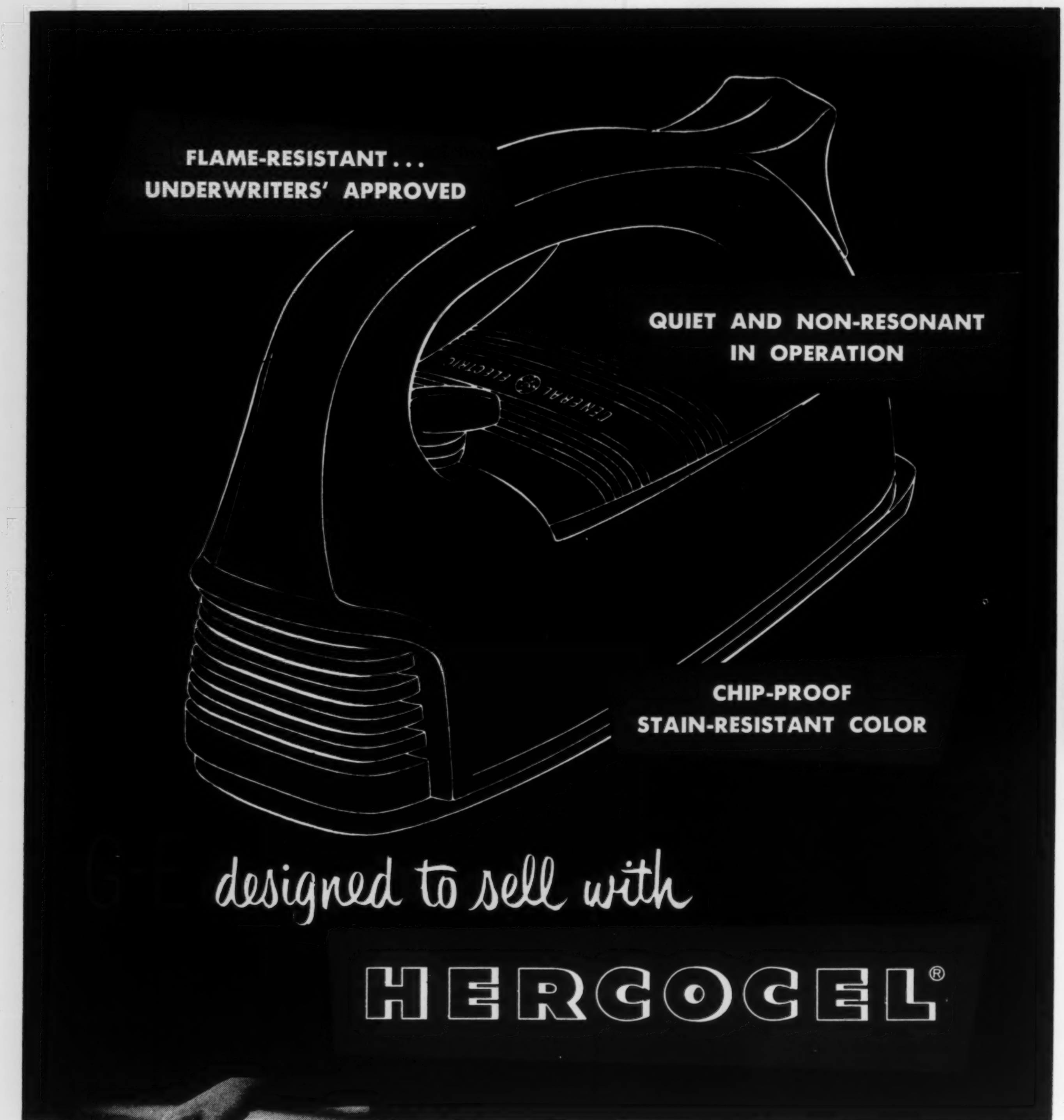
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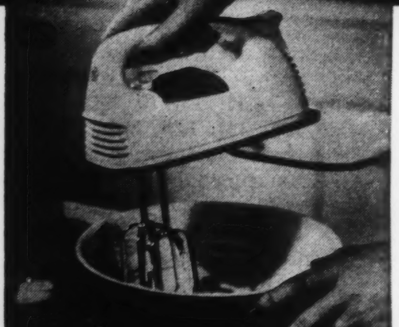

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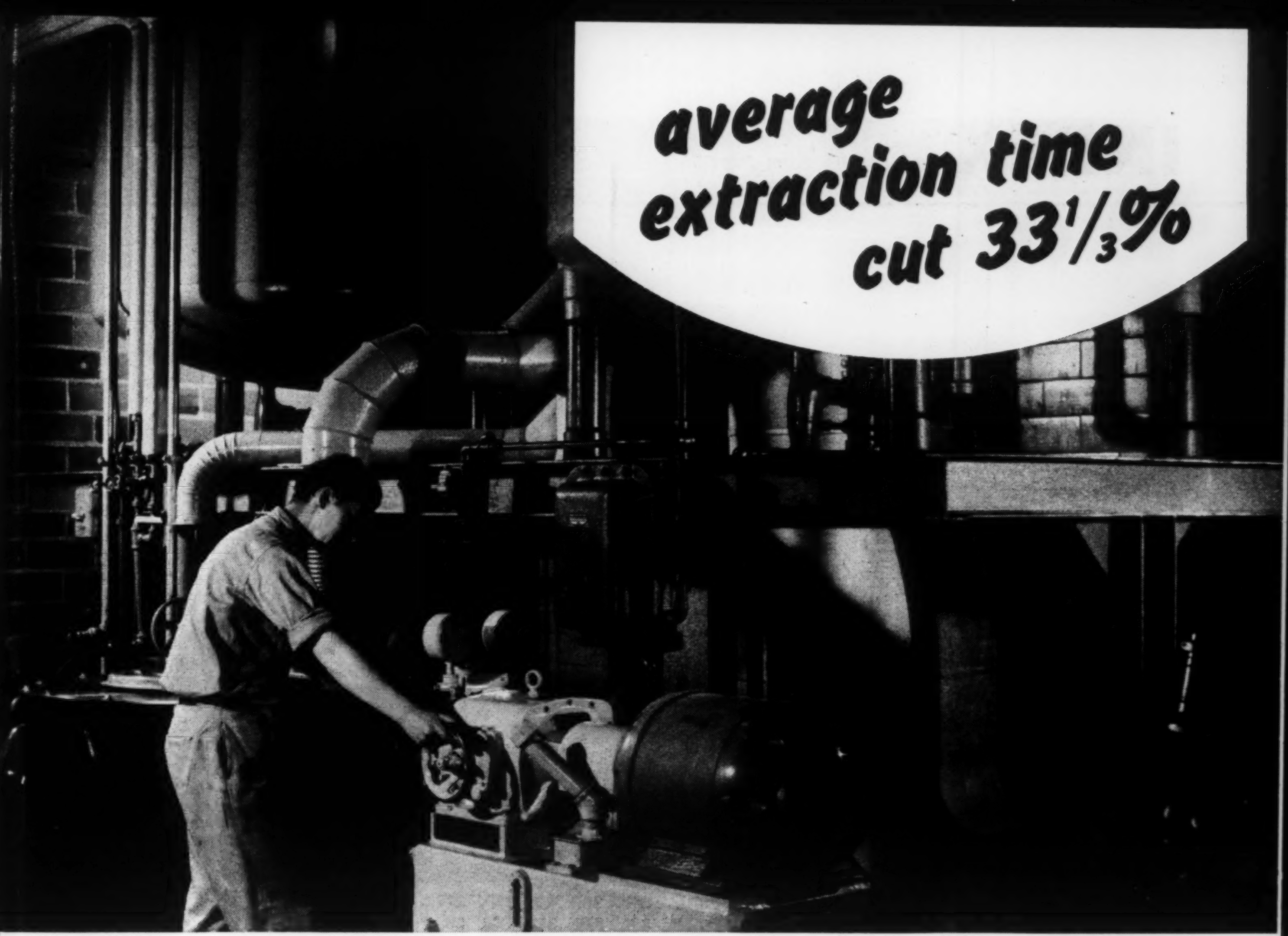

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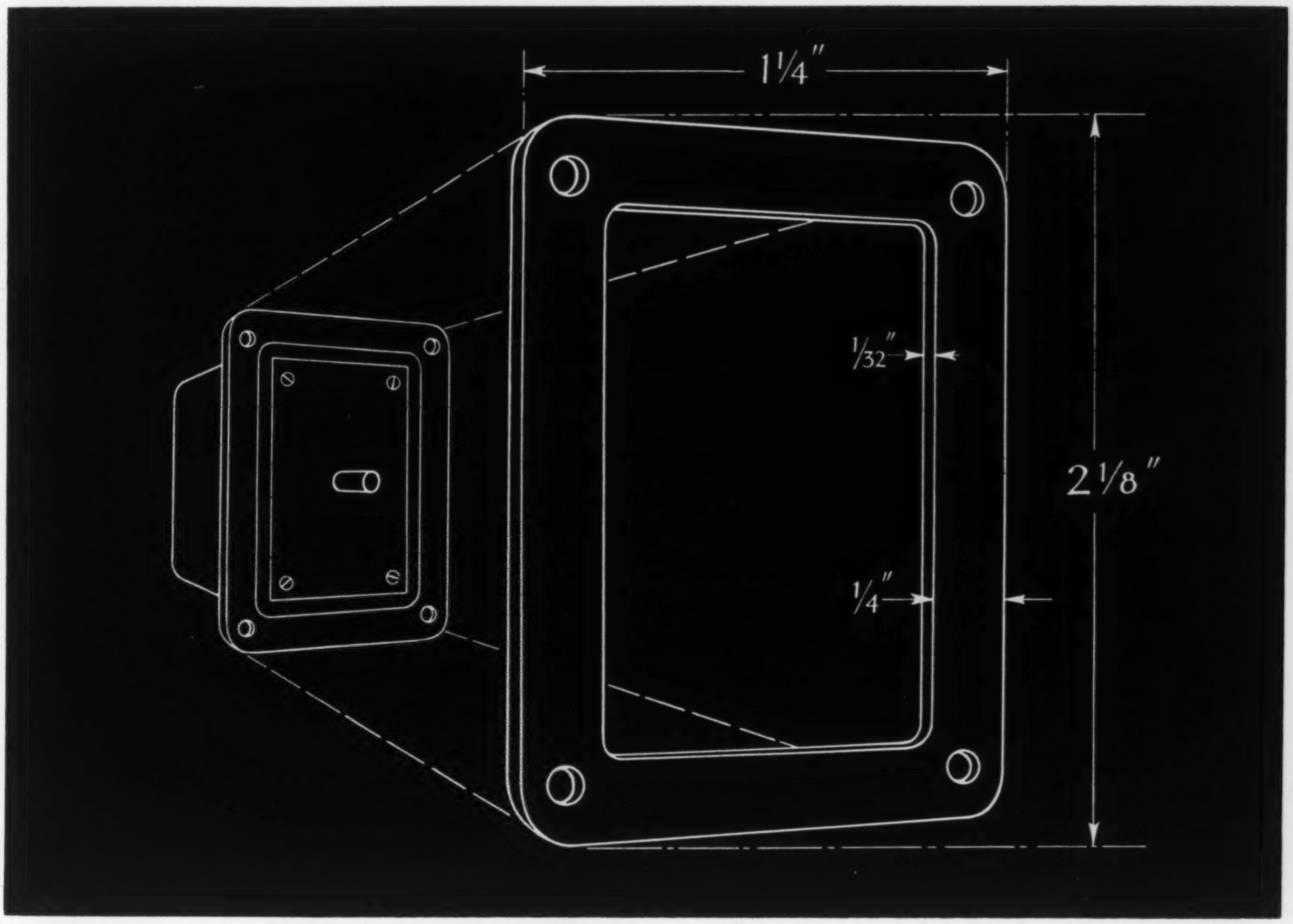

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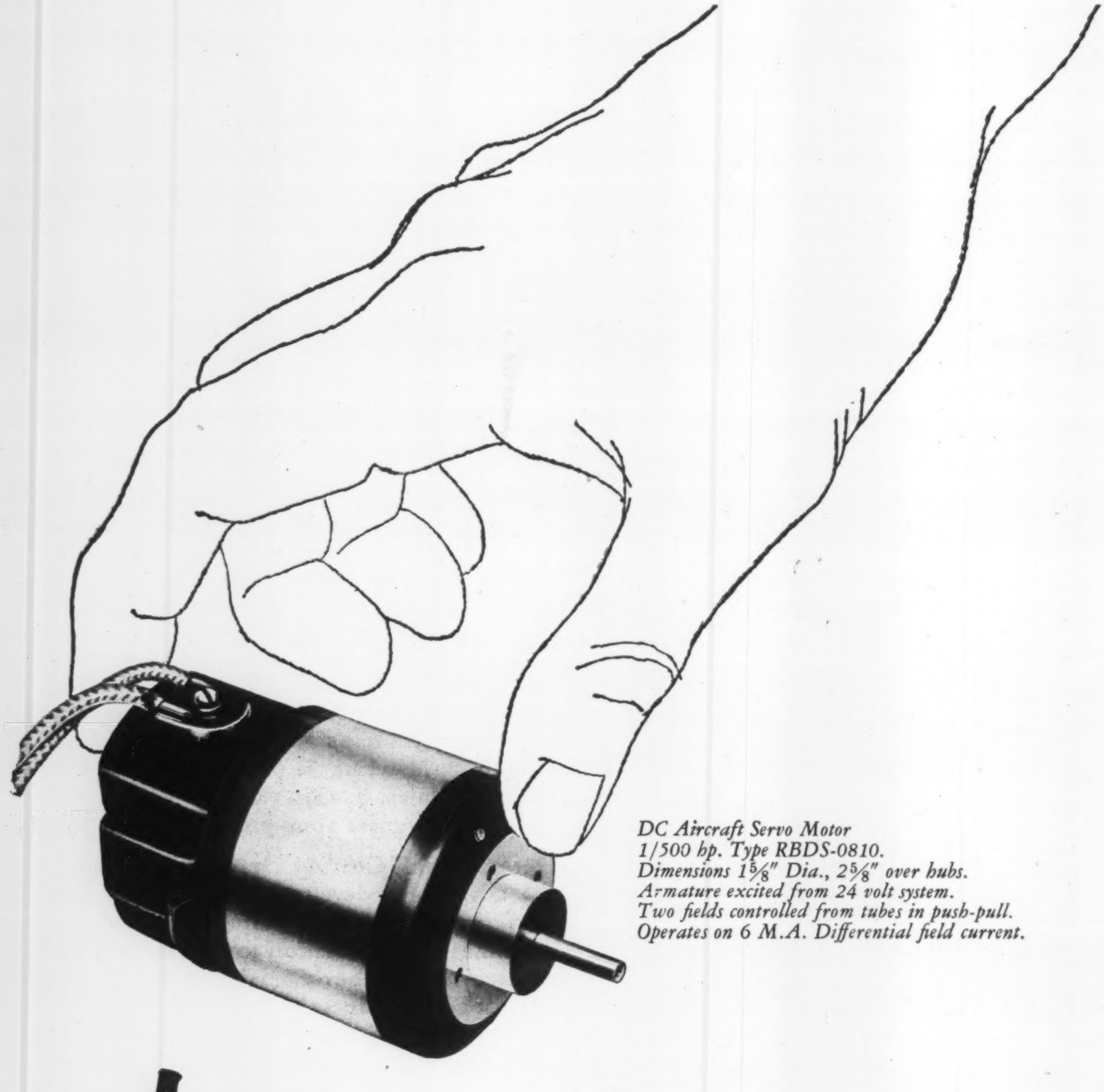

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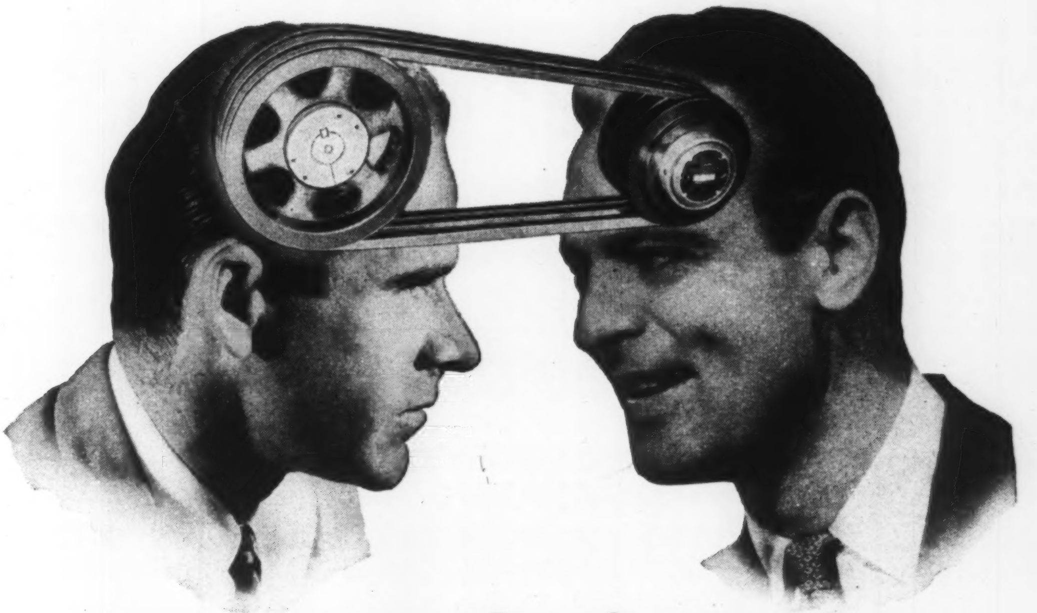

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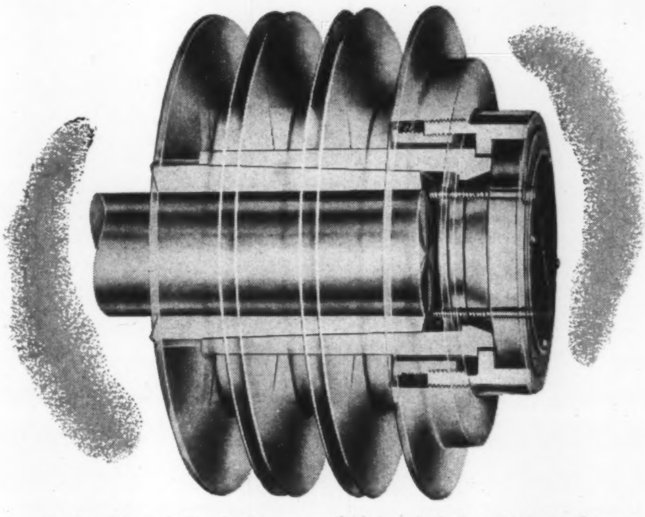

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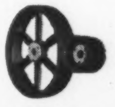

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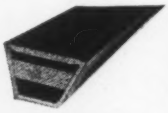

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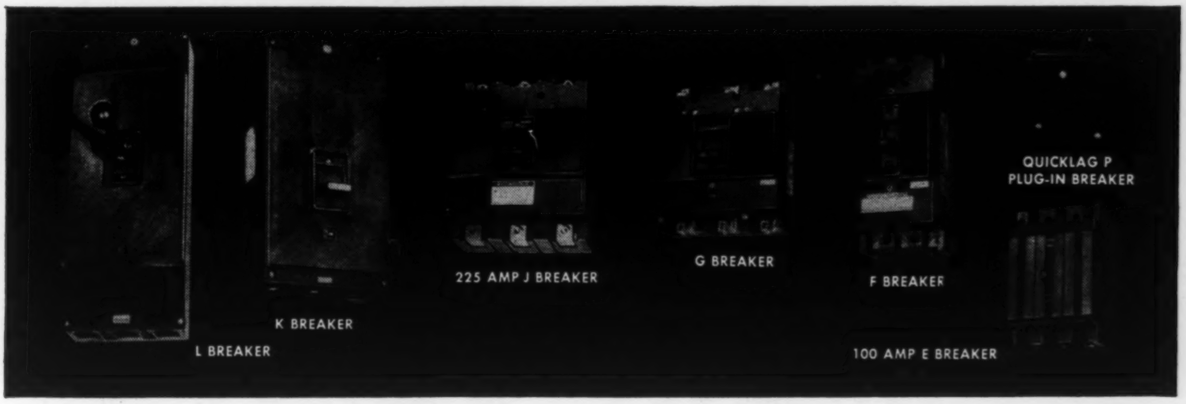

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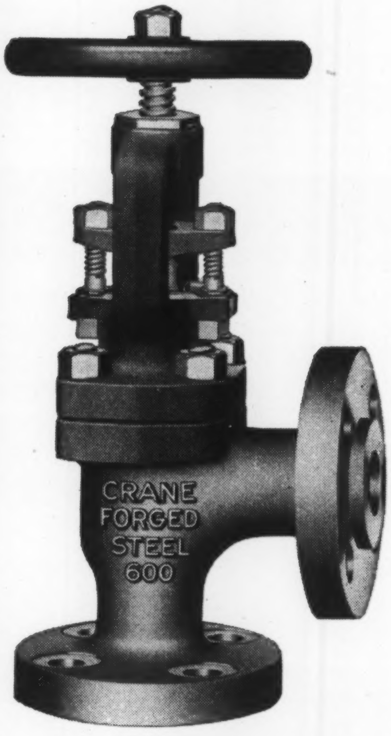
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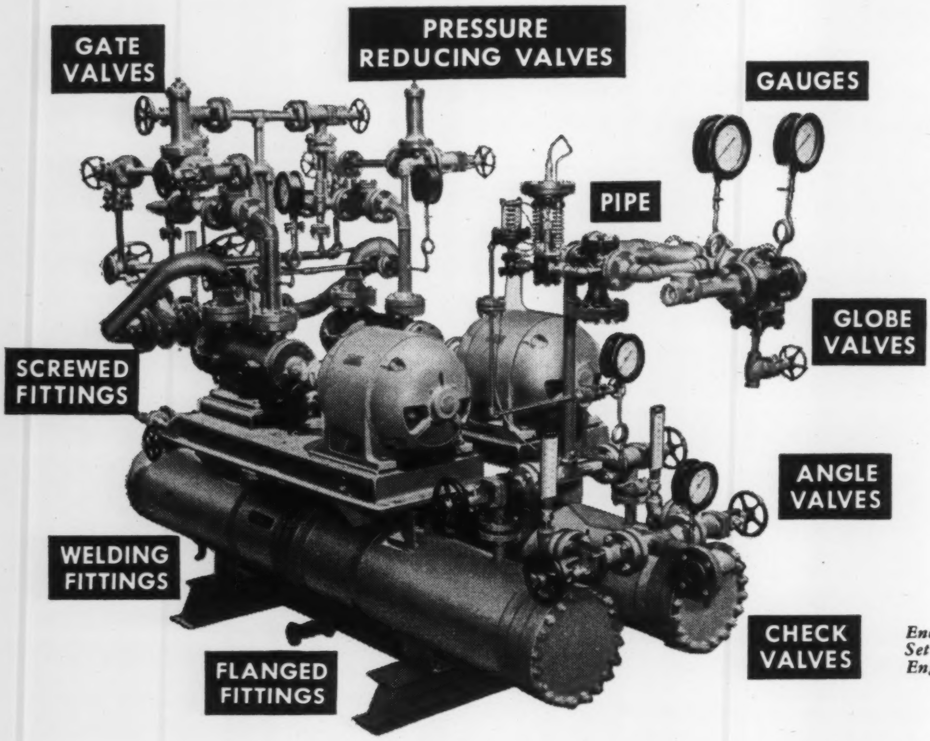
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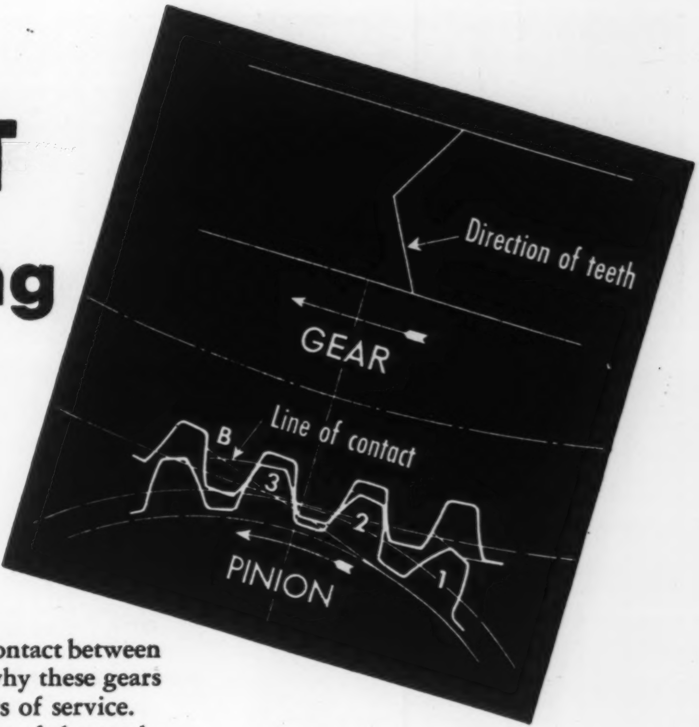

This diagram, which illustrates the nature of the contact between a pair of Farrel-Sykes herringbone gears, shows why these gears continue to operate smoothly after so many years of service.

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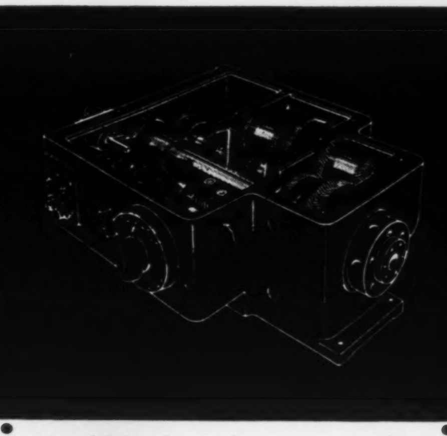
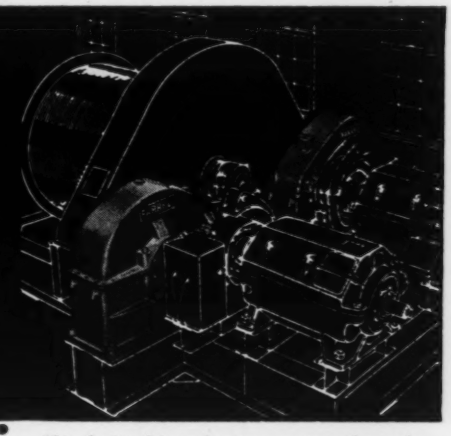
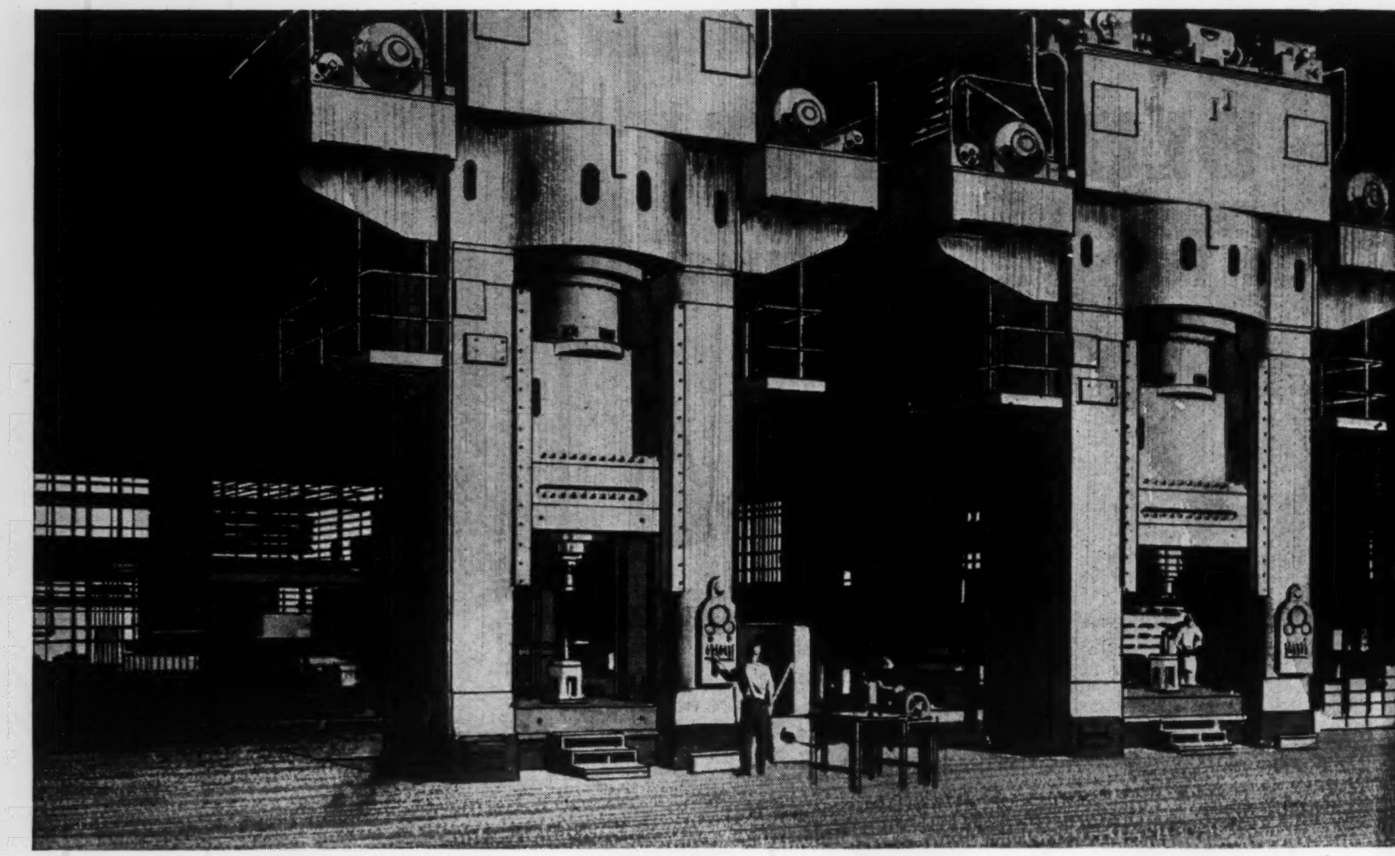


Farrel-Sykes herringbone gears used in the headstock of a lathe.



Skip hoist driven by two motors through Farrel speed reducers.



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Commercial facilities supported by specialized engineering and development departments are now available to industry for the production of parts by the exclusive Mullins Steel KOLDFLO* Process.

Now for the first time the economies of this process which shapes cold steel into finished parts is made available to American industry.

The Mullins Steel KOLDFLO Process is completely and exclusively different from any other extrusion process. The finished products come from the presses with smoothness, hardness, strength and precision required, and all of these features are acquired in the process from the use of low carbon, low cost steel.

The process can better and more economically make a wide variety of finished products. Some of these products have already been produced and are shown on the opposite page. They are used in many different fields of manufacture.

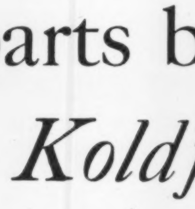
The new and expanded facilities for commercial use make possible the production of cold-formed, hollow parts into finished shapes and a wide variety of configurations and are in lengths from 6″ to 36″ and in diameters from 2″ to 6″.

Because the Mullins Steel KOLDFLO Process is so new, the question "What is KOLDFLO?" has been asked us many times. To answer this question, we have prepared a booklet entitled **"Product Design Guide."**

This Design Guide will be valuable to executives, engineers and designers in studying the cost-saving possibilities of this process.

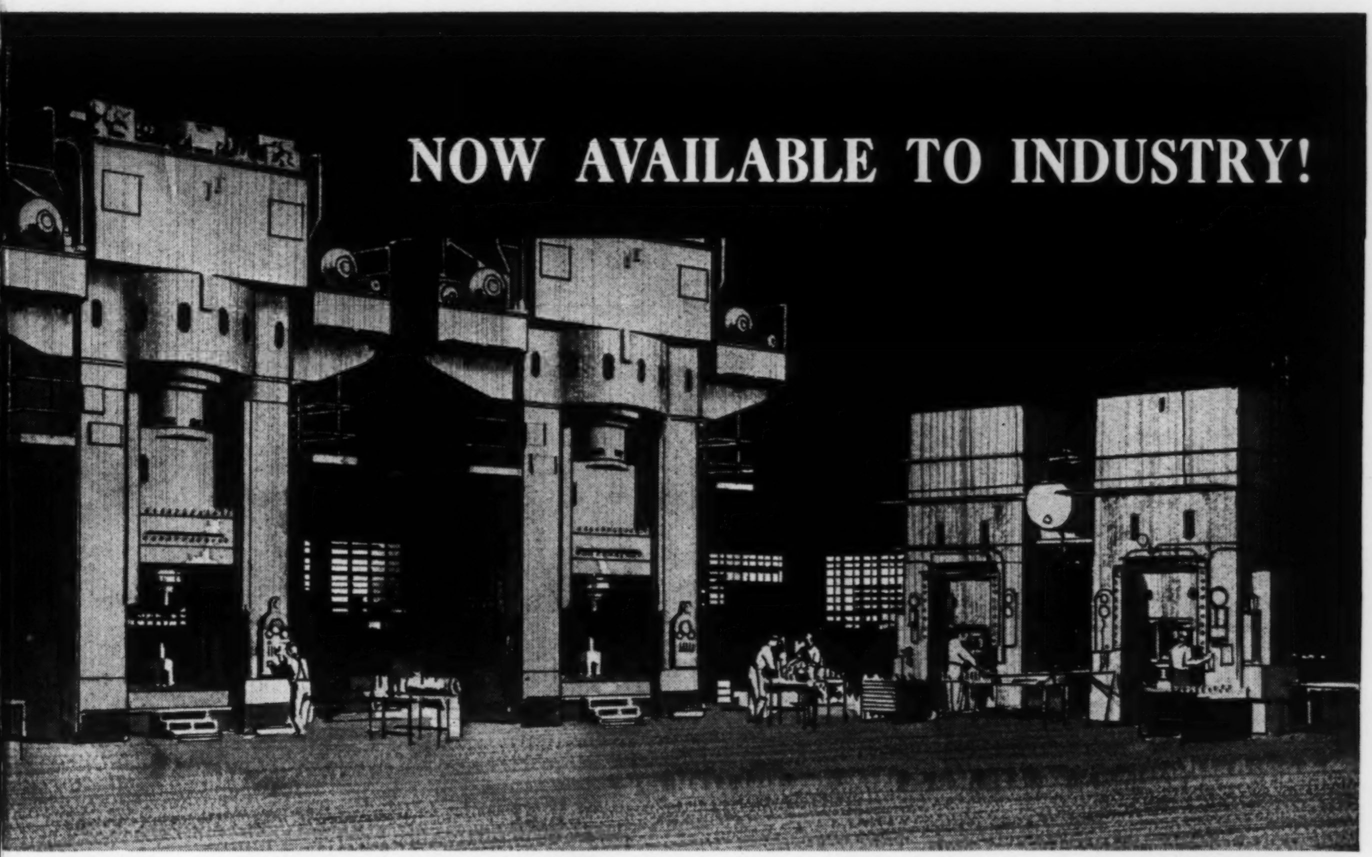
Koldflo **Division**
MULLINS MANUFACTURING CORPORATION
SALEM, OHIO

*KOLDFLO is a trade-mark of Mullins Manufacturing Corporation.

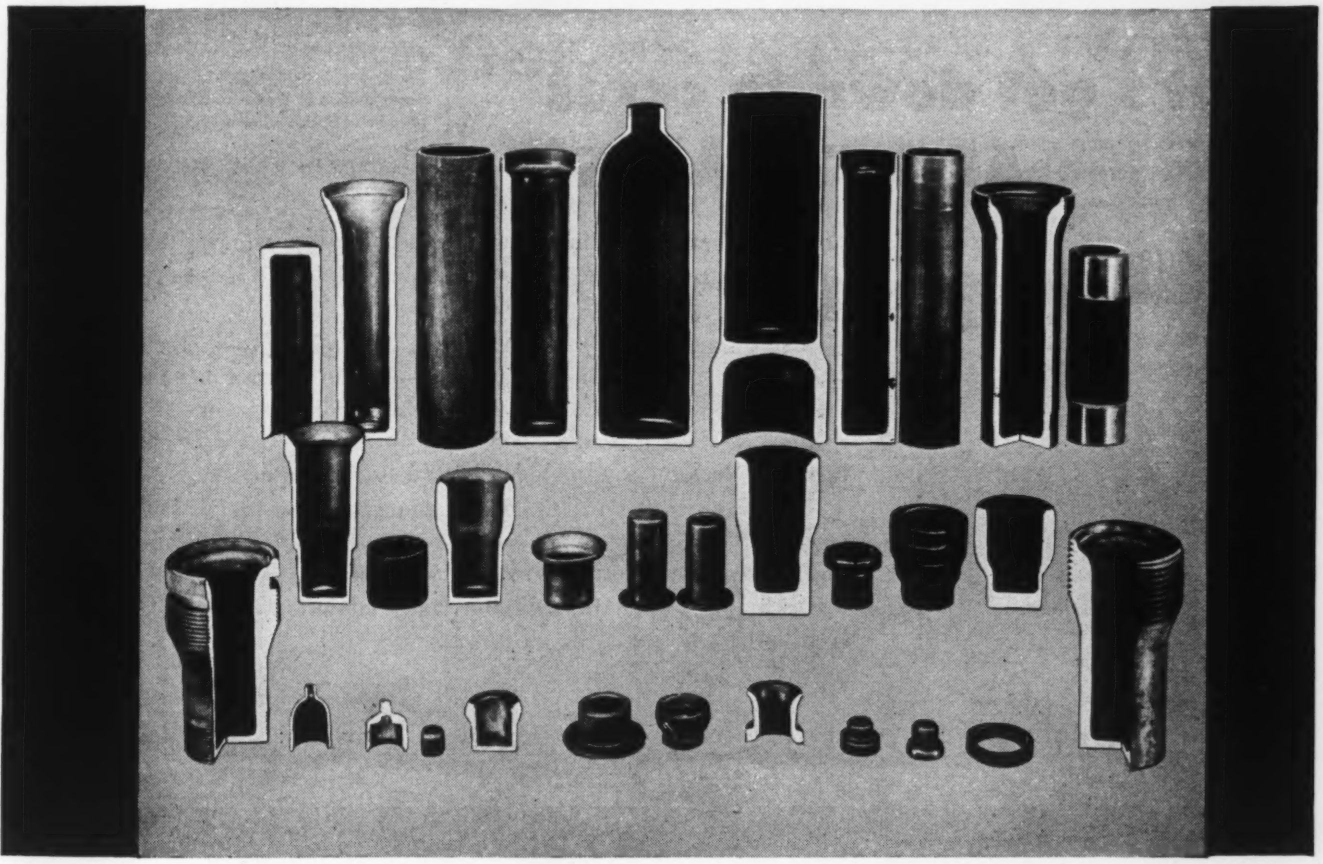


Send today for your free copy of "Product Design Guide."

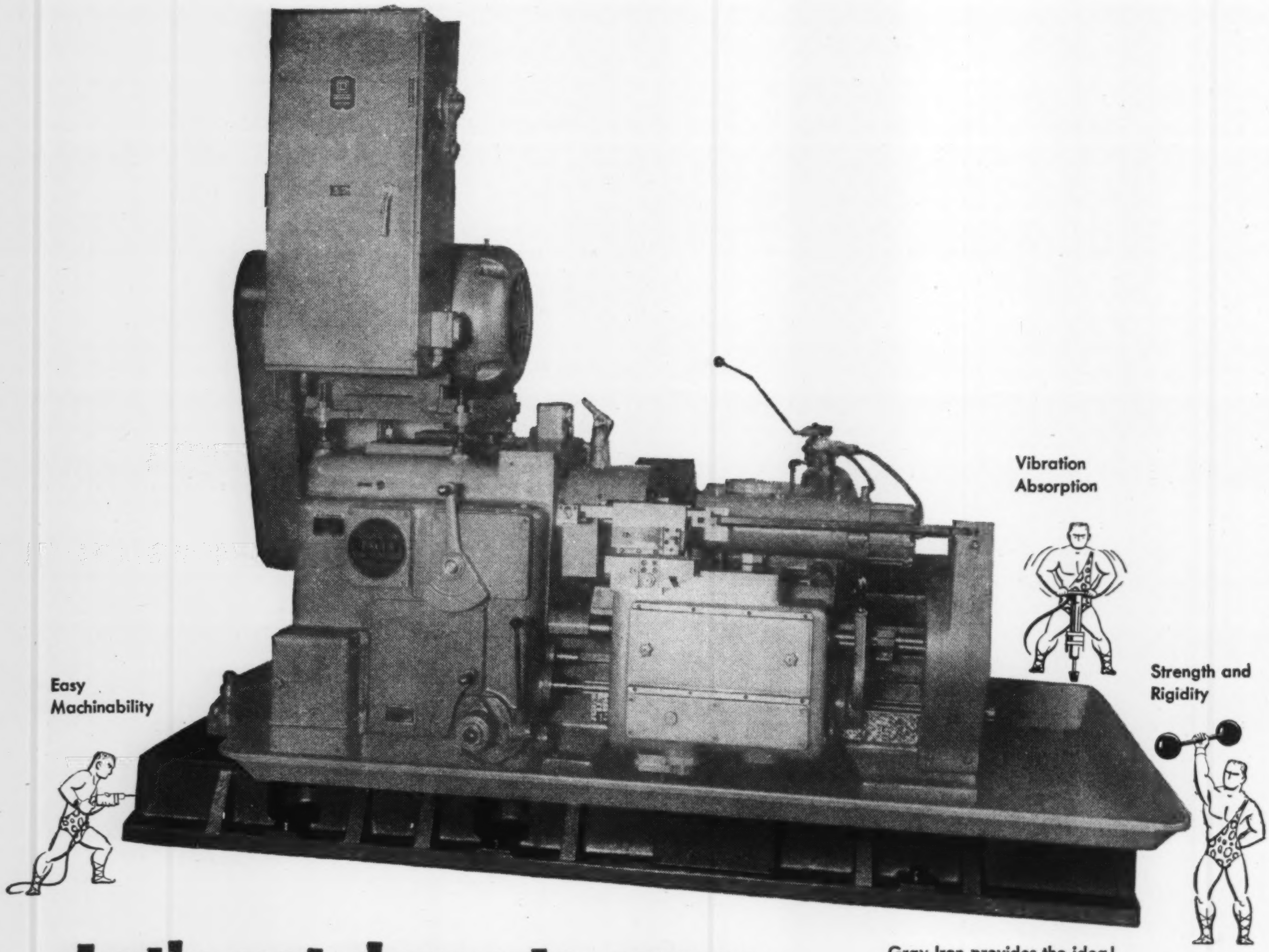
NOW AVAILABLE TO INDUSTRY!



These six giant presses are the beginning of the Mullins Steel KOLDFLO commercial production facilities.



These parts have already been produced and hundreds of other similar parts can be produced by the Mullins Steel KOLDFLO Process with a definite savings in steel, manpower, machine tools, plant space and dollars.



Gray Iron provides the ideal combination of characteristics for the base of this automatic lathe.

Let's get down to cases ABOUT BASES!

GRAY IRON Characteristics Include:

- Castability
- Low Notch Sensitivity
- Heat Resistance
- Durability
- Machinability
- Rigidity
- Wear Resistance
- Corrosion Resistance
- Vibration Absorption
- Wide Strength Range

The manufacturer of this automatic lathe had previously used a fabricated steel base. To cut down delivery time and reduce costs, a switch was made to a cast Gray Iron base.

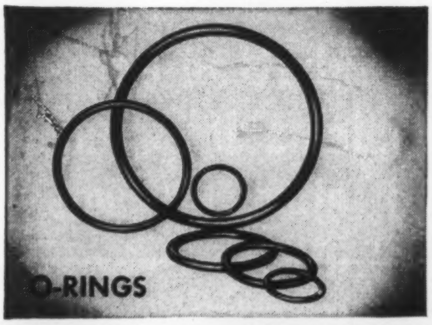
In the manufacturer's own words . . . "in addition to appreciable cost savings, delivery time to our machine shop is about one-eighth that of fabricated steel. Because of the rigidity inherent in the casting, we have a base which is easy to machine, absorbs vibration, and does the kind of a job our customers expect."

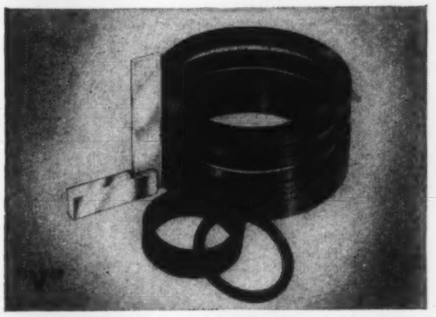
When you "get down to cases" about machine tool bases—or any other application requiring the unique combination of advantages listed at the left—be sure to investigate Gray Iron! Write for technical information on the many advantages of the Gray Iron casting process.

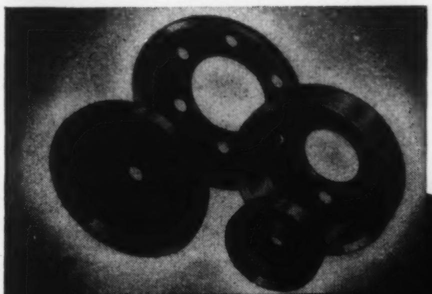
Make it Better with Gray Iron • **Second largest industry in the Metal-working field**

GRAY IRON FOUNDERS' SOCIETY, INC.

NATIONAL CITY-E. 6th BLDG., CLEVELAND 14, OHIO







Oil Seals! made to your specs with leather or synthetic rubber at G&K-INTERNATIONAL

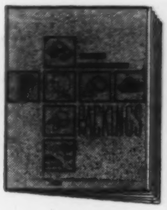
Oil Seals are a big part of our business — have been for years. And among our customers are the best-known industrial concerns in the country.

So if it's Oil Seals you need, we make them. We want to figure on your requirements. We have the equipment, the skilled people, the knowledge of leather and rubber. Our quotation will tell you how economically we can produce Oil Seals. The first order will prove to you how efficiently we can meet your needs.

You can always depend upon G&K-INTERNATIONAL as a major source for other sealing devices: O-Rings, Cups, Flanges, U's and V's as well as special packings made to order. And look to us for replacement packings to JIC standards, and particularly for the hard-to-get larger sizes in leather.

New Packings Catalog

Probably the most comprehensive catalog and manual in existence today. Covers all types with latest tables. Also helpful application data. Write for your copy today! IT'S FREE.

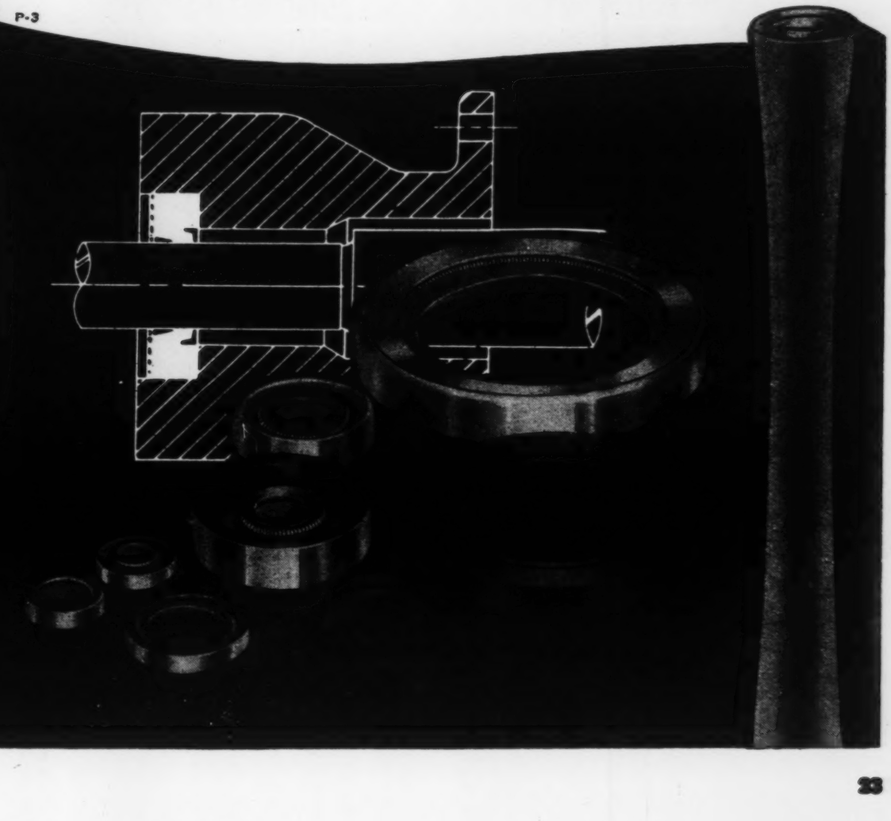


G&K GRATON AND KNIGHT INTERNATIONAL

GRATON & KNIGHT COMPANY
Established 1851
Worcester 4, Massachusetts

INTERNATIONAL PACKINGS CORPORATION
Graton & Knight Company Affiliate
Bristol, New Hampshire

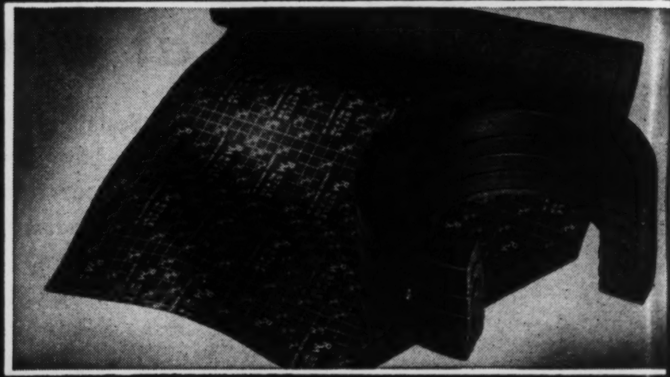
P-3

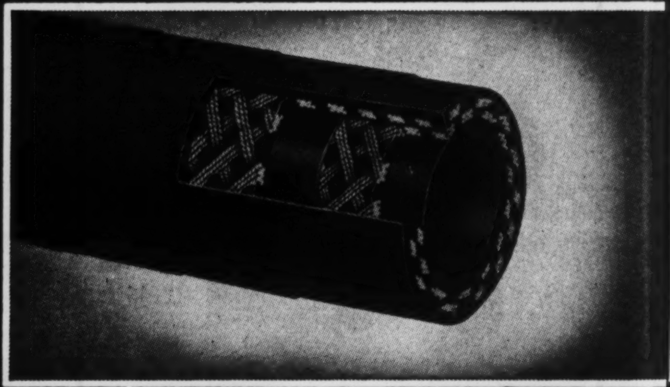


OIL SEALS

Made of leather or rubber, usually incorporating a metal case or supporting ring. Installed around a rotating or reciprocating shaft to retain or exclude fluids, semi-liquids, dust and dirt. Provides single or multiple sealing lips. Oil Seals are generally made to exact specifications to meet requirements.

Design people find Raybestos-Manhattan engineering service helpful on problems involving Asbestos, Rubber, Sintered Metal and Teflon* Products





Brake Blocks, Linings and Clutch Facings

Fan Belts and Radiator Hose

Mechanical Packings and Gaskets

Abrasive and Diamond Wheels

Industrial Drive Belts

Industrial and Automotive Hose

Conveyor Belts

Rubber Lined and Covered Equipment

SPECIALISTS IN ASBESTOS, RUBBER, SINTERED METAL

To better serve you PROMPTLY.. **So that R/M sales, research and engineering can best coordinate to handle your problems . . . and so that we can serve you with least delay . . . please wire, phone or write the division listed under the product in which you are interested.**

PACKINGS, GASKETS
ASBESTOS TEXTILES AND TEFLON PRODUCTS

Raybestos-Manhattan makes a wide variety of packings and gasket sheets, and an unusual number of asbestos textiles. Illustrated are two packings typical of the diversity of the R/M Packing line. K-68® is a compressed asbestos sheet with Neoprene binder. It has outstanding resistance to solvents of the gasoline and aromatic types. Vee-Flex® Packing Rings are uniquely designed to provide automatic sealing. R/M also stands ready to meet your specifications for Teflon packings, rods, sheets, tubes, tape and fabricated parts.

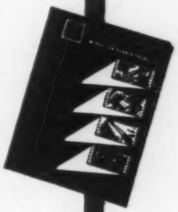
**Du Pont trade-mark for its tetrafluoroethylene resin*

PACKINGS, GASKETS,
ASBESTOS TEXTILES
AND TEFLON PRODUCTS

Packing Division or
Asbestos Textile Division
Raybestos-Manhattan, Inc.
Manheim, Pa.
Manheim 5-2211

MECHANICAL RUBBER PRODUCTS

If your design project calls for hose, chances are R/M engineers have *already* designed just the hose you need. Special types for acid, oil, sandblast, paint spray, chemicals—types for easy flexing like Homoflex for air, water and other general use. Homoflex is typical of R/M engineering—it's strong, yet light and "flexible as a rope," with no preset twist. Cover and tube are inseparably joined through the specially designed strength member. If none of these fit your requirements R/M will make a hose that does! Of course, R/M also can help solve your problems on transmission and conveyor belts, V-belts and molded rubber products. Let R/M work with you.



MECHANICAL
RUBBER PRODUCTS

Manhattan Rubber Division
Raybestos-Manhattan, Inc.
Passaic, N.J.
Gregory 3-2000

FRICTION MATERIALS

Raybestos-Manhattan makes a variety of sintered metal products like those shown. These "Stop-and-Go" products of powdered metal are increasingly important in the automotive, aviation and earthmoving industries, especially where operations involve extreme temperatures. They are typical of the many different clutch and brake parts made by R/M. Whether of metal, or of woven or molded asbestos, every R/M friction element is engineered to meet your specific operating conditions.

ENGINEERING
INFORMATION
R/M

FRICTION
MATERIALS

Equipment Sales Division
Raybestos-Manhattan, Inc.
6010 Northwest Highway
Chicago 31, Ill.
ROdney 3-2400

RAYBESTOS-MANHATTAN, INC.

ubber Covered
Rolls

Sintered Meta l
Friction Elements

Asbestos
Textiles

Teflon Tape, Packings,
Sheets, Rods, Tubes

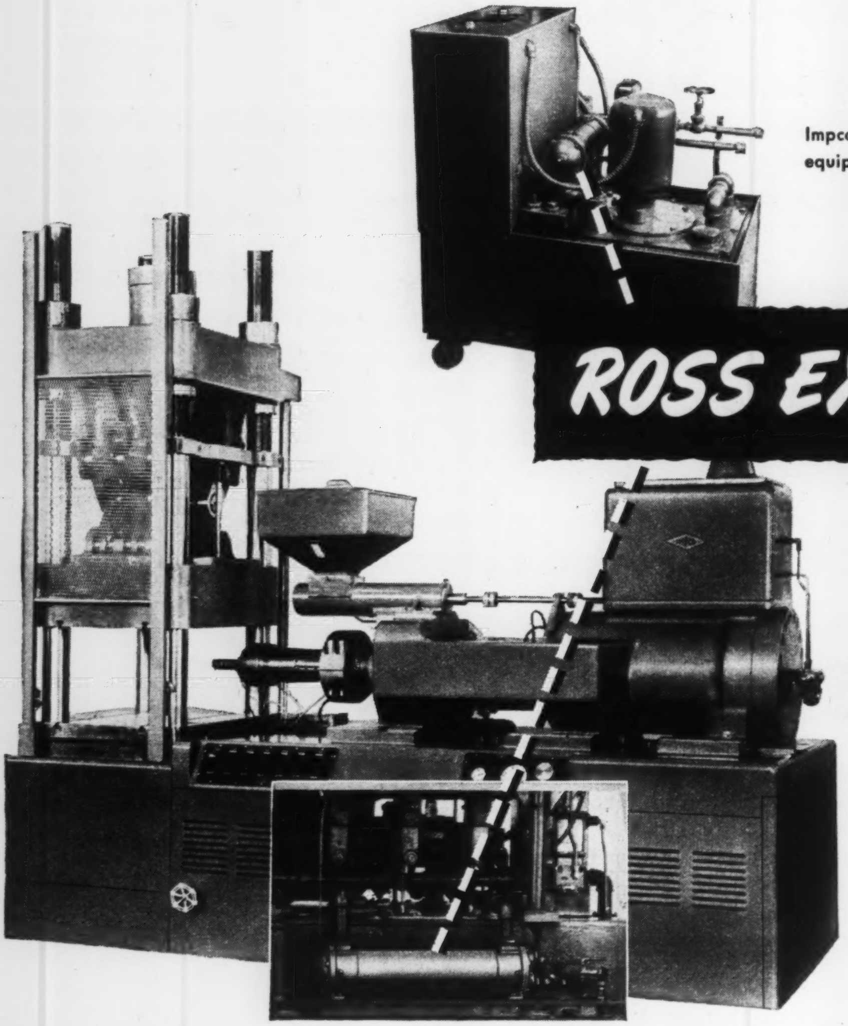
AND TEFLON PRODUCTS

FACTORIES: Passaic, N.J. • Manheim, Pa. • Bridgeport, Conn. • No. Charleston, S.C. • Crawfordsville, Ind. Neenah, Wis. • Peterborough, Ontario, Canada

Manufacturers of Mechanical Rubber Products • Brake Linings • Brake Blocks • Clutch Facings • Sintered Metal Products • Fan Belts • Radiator Hose • Rubber Covered Equipment • Asbestos Textiles • Teflon Products Packings • Abrasive and Diamond Wheels • Bowling Balls

R/M

for twofold temperature control in this Impco plastic molding equipment



Impco No. 3 Temperature Regulator, equipped with a Ross Exchanger.

ROSS EXCHANGERS

Impco VF 822A, 22-Ounce Injection Molding Machine, equipped with a Ross Exchanger.

At full 22-ounce capacity, this IMPCO Injection Molding Machine is designed to apply 15,000 psi on the material.

To maintain that pressure — *to guard against hydraulic power losses through pump slippage* — Impco furnishes a Ross Type BCF Exchanger. Thinned-out hydraulic fluid, caused by overheating, is thus prevented. Ross Exchangers keep temperatures under control. "Every plastic molding machine we manufacture utilizes a Ross Exchanger," states the Improved Paper Machinery Corporation. *Productivity is thereby insured!*

In those installations where an Impco Temperature Regulator is used—a Ross Exchanger again plays a vital role . . . safeguarding against rising temperatures of the oil or water pumped through the mold. For, Ross Exchangers are also standard components of this IMPCO equipment. Hence, dependable protection becomes twofold. *Qualitative control is also insured!*

So too, do other leading manufacturers, like Impco, build temperature control into their products by factory-installing Ross Exchangers on *all* types of hydraulic equipment: *extrusion and metal drawing presses, die casting machines, calenders, stoker drives, as well as injection and compression molding machines.*

Available in a wide range of pre-engineered, fully standardized designs and constructed of durable copper and copper alloy, Ross Type BCF Exchangers have earned universal acceptance. To find out what they can do for you, write for Bulletin 1.1K5.

KEWANEE-ROSS CORPORATION
DIVISION OF AMERICAN RADIATOR & STANDARD SANITARY CORPORATION
1429 WEST AVENUE • BUFFALO 13, N. Y
In Canada: Kewanee-Ross of Canada Limited, Toronto 5, Ont.

ROSS
EXCHANGERS

KEWANEE-ROSS PRODUCTS

Serving home and industry: AMERICAN-STANDARD • AMERICAN BLOWER • CHURCH SEATS & WALL TILE • DETROIT CONTROLS • KEWANEE BOILERS • ROSS EXCHANGERS

A faster way to select better clutch facings

The test equipment shown above is the key to saving you time in getting the most efficient friction material for your particular wet clutch.

Normally, finding the right material means installing experimental facings in test clutches until one is found that meets performance specifications.

For the initial tests, there's no way to escape this educated guesswork. Every clutch differs if only in details, and even minor differences can create entirely new facing problems.

When you evaluate a few Armstrong facings in your clutch, however, field test results then can be compared with Armstrong's laboratory data on these same compounds. From this comparison, experienced compounders establish the direction in which field-tested compounds must be modified to provide the torque and engagement characteristics you specify. This orderly, basic approach to compounding saves you the time of testing random "pinch of this and pinch of that" facing compounds.

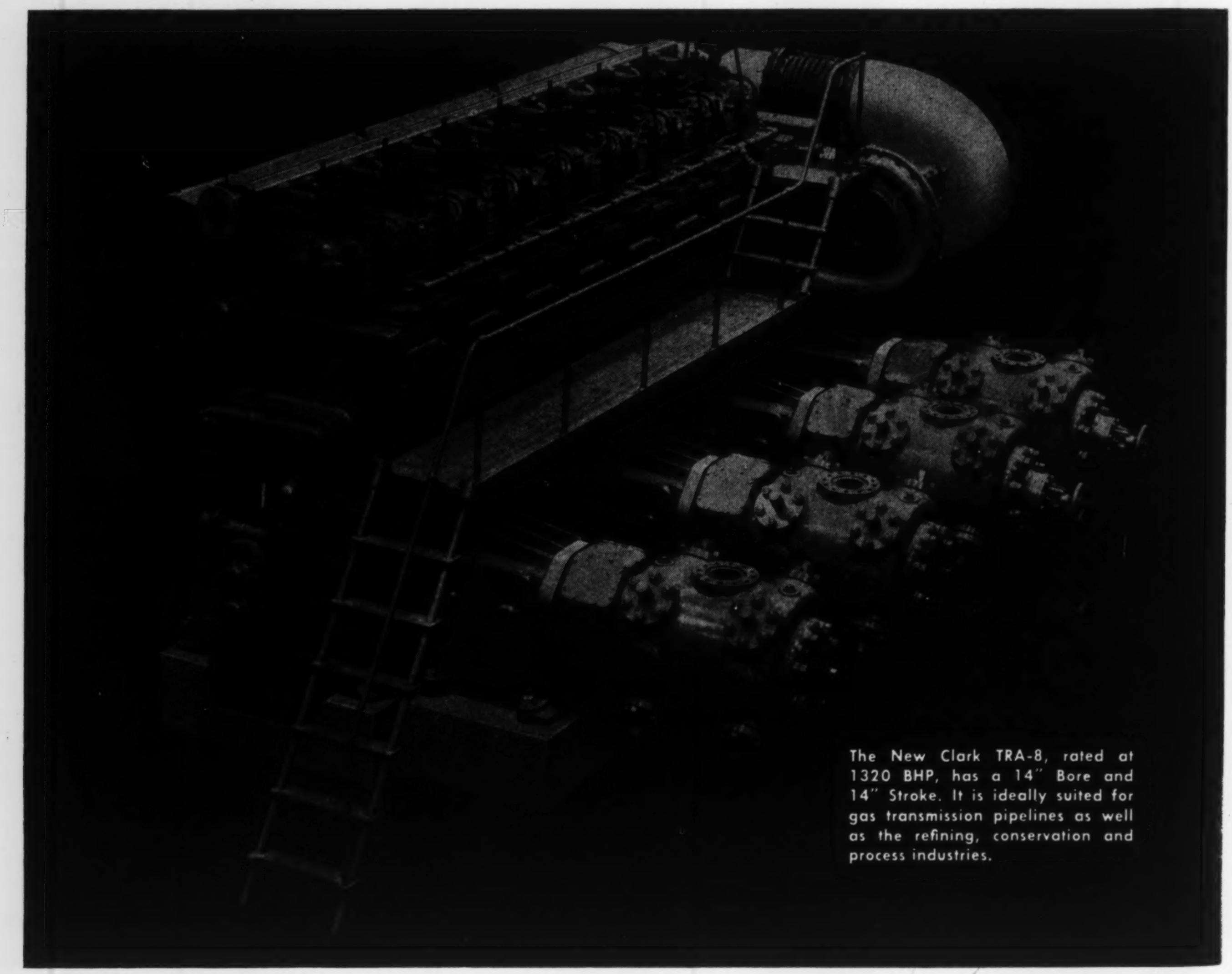
Relative torque and engagement characteristics for Armstrong's many cork compounds have been established under the standard, controlled conditions provided by this equipment. Points of difference created by formulation changes are easily detected and cataloged. This means that you have better assurance of selecting the most suitable facing material.

For more information, write, outlining your problem. Also reserve a copy of "Armstrong's Friction Materials." This manual is now in preparation. It will give you information of help with either your current or your "dream" clutch applications. Write Armstrong Cork Company, Industrial Division, 7206 Dean Street, Lancaster, Pennsylvania.

ARMSTRONG'S FRICTION MATERIALS

IT'S HERE! a

The NEW Clark 2-Cycle



The New Clark TRA-8, rated at 1320 BHP, has a 14" Bore and 14" Stroke. It is ideally suited for gas transmission pipelines as well as the refining, conservation and process industries.

Clark Continues to Set the Pace in Compressor Progress

revolutionary compressor development!

Turbo-Charged "Right Angle"

It's here — after seven years of intensive development. Clark revolutionizes compressor design with the first 2-Cycle Turbo-Charged Gas Engine Driven Compressor . . . the TRA. Another Clark first! A precedent-shattering development that makes possible —

50% MORE POWER

Developing 1320 bhp, the TRA-8 delivers 50% more power than any comparable compressor, with *no* en-croachment on overload carrying ability.

SHARPLY REDUCED FUEL CONSUMPTION

The TRA is conservatively rated *and guaranteed* to burn substantially less fuel than *any* gas engine driven compressor now built.

25% LESS COOLING WATER LOAD

(Including scavenging air intercooler load.) Vast amounts of waste heat are recovered from the exhaust gases by the Clark Turbo-Charger and are converted to useful work.

FLAT FUEL CONSUMPTION CURVE

Fuel consumption remains practically constant over a wide range of load conditions.

QUIET

Energy goes into power, rather than noise. Much quieter than a conventional gas engine driven compressor. No exhaust pulsations.

UNPRECEDENTED RUGGEDNESS

Tremendous stamina, unapproached by any other compressor design. Conservative BMEP rating.

COMPACT IN-LINE DESIGN

Very economical of floorspace, foundations and building requirements, yet highly accessible.

●

The Clark TLA, with 17″ bore and 19″ stroke, is also available when units of even greater horsepower than the TRA are required. For complete engineering details — the facts behind this revolutionary compressor development — see your nearest Clark representative and write for Bulletin 130.

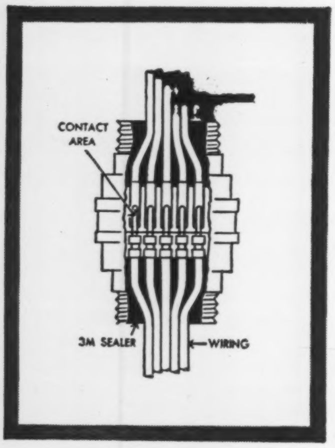
CLARK BROS. CO. • OLEAN, N. Y.
DIVISION OF DRESSER OPERATIONS, INC.
SALES OFFICES IN PRINCIPAL CITIES THROUGHOUT THE WORLD

CLARK compressors

© 1953, Clark Bros. Co., Division of Dresser Operations, Inc.

See what adhesives are doing today!

Keeping your power dry!



Protecting our shores from invasion is only one of the jobs assigned to Navy aircraft. Another task, equally important, is for the plane to protect itself against its own "natural" enemies.

For instance, consider the possible effects of salt air and water, of moisture condensation, of vibration on the electric wiring that delivers power throughout the plane. How quickly these elements would destroy the aircraft—if not checked.

To help protect these power lines, 3M, working with McDonnell engineers and the U.S. Navy, developed EC-1120PC—a potting compound, not affected by vibration, that provides a permanent seal for wiring in plugs against moisture and salt air. It helps to keep your power dry!

See what adhesives can do for you . . .

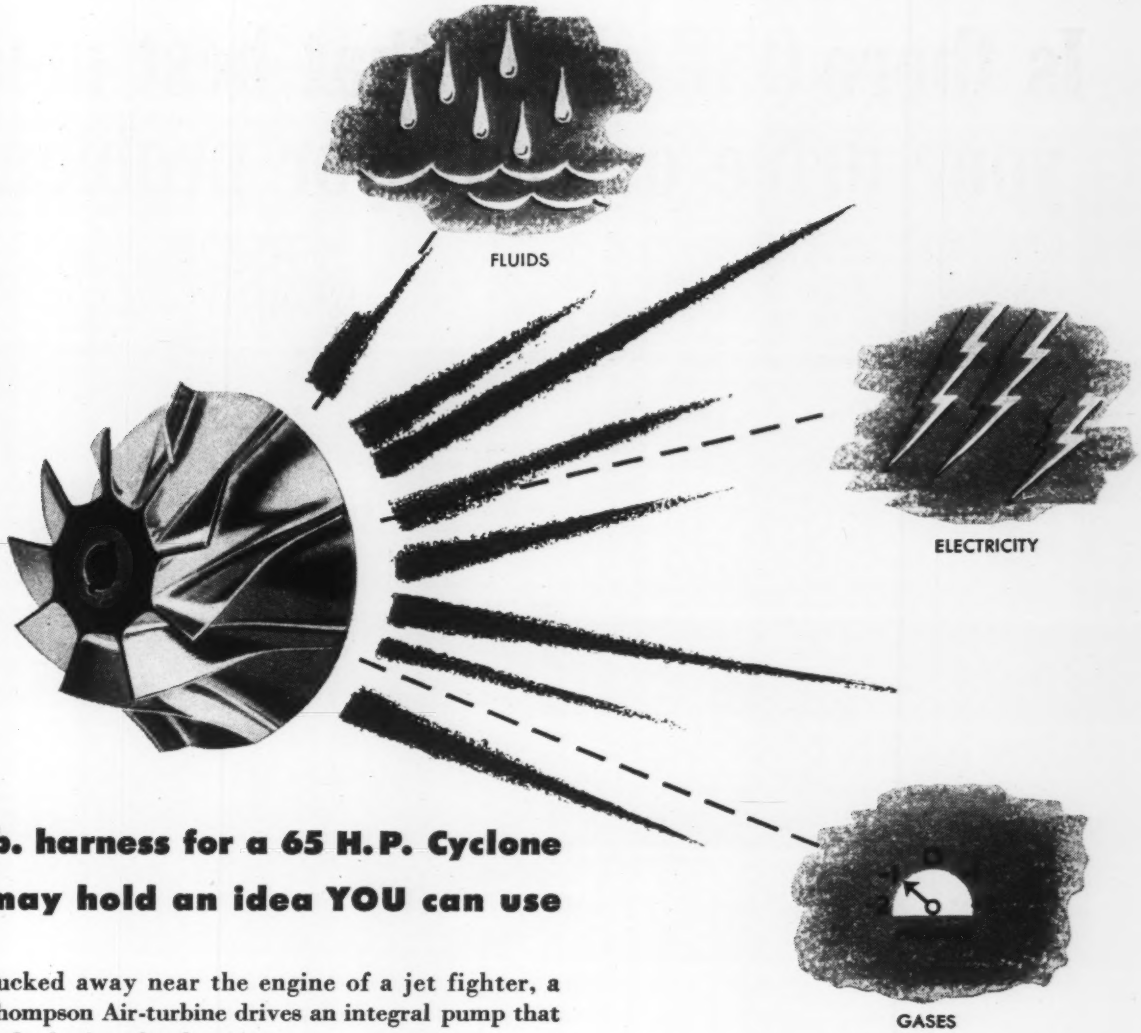
There are virtually thousands of other 3M products developed for specific uses such as this, or for more general purposes. For the facts on 3M adhesives, sealers and coatings designed especially for industrial use, call in your 3M sales representative, or write directly to 3M, Dept. 196, 411 Piquette Ave., Detroit 2, Michigan.

3M
COMPANY

ADHESIVES•COATINGS•SEALERS

MINNESOTA MINING AND MANUFACTURING COMPANY
ADHESIVES AND COATINGS DIVISION • 411 Piquette Ave., Detroit 2, Michigan
GENERAL SALES OFFICES: ST. PAUL 6, MINN. • EXPORT: 122 E. 42 ST., N.Y. 17, N.Y. • CANADA: LONDON, ONT.

MAKERS OF "SCOTCH" BRAND PRESSURE-SENSITIVE ADHESIVE TAPES • "SCOTCH" BRAND SOUND RECORDING TAPE • "SCOTCHLITE" BRAND REFLECTIVE SHEETINGS • "3M" ABRASIVE PAPER AND CLOTH • "3M" ADHESIVES AND COATINGS • "3M" ROOFING GRANULES • "3M" CHEMICALS



This 12 lb. harness for a 65 H.P. Cyclone ...may hold an idea YOU can use

Tucked away near the engine of a jet fighter, a Thompson Air-turbine drives an integral pump that feeds the jet after-burners.

Coupled to an electrical alternator, a Thompson Air-turbine drive delivers vast amounts of horsepower at micro-precise speed, regardless of fluctuations in load.

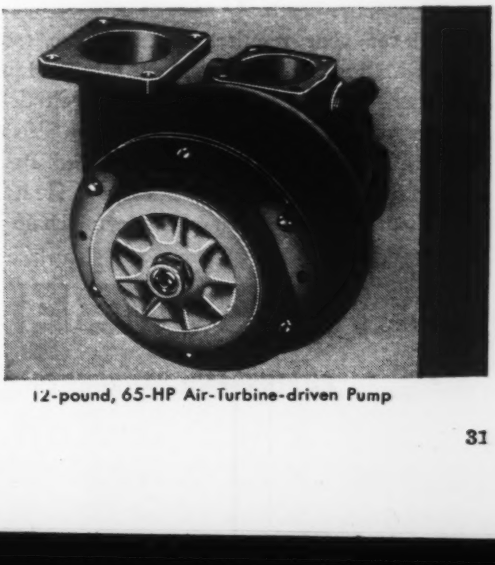
These Thompson turbines pack abundant power into small space, with minimum weight. What's more, they use air, always available at low cost.

Industry is discovering dozens of new uses for these Thompson Air-turbines . . . in a wide range of sizes and power. You may find it worth-while to call in a Thompson representative to tell you what we know about designing and building Air-turbines. To find out how you can put them to work in *your* application, present or future, write . . .

ACCESSORIES DIVISION

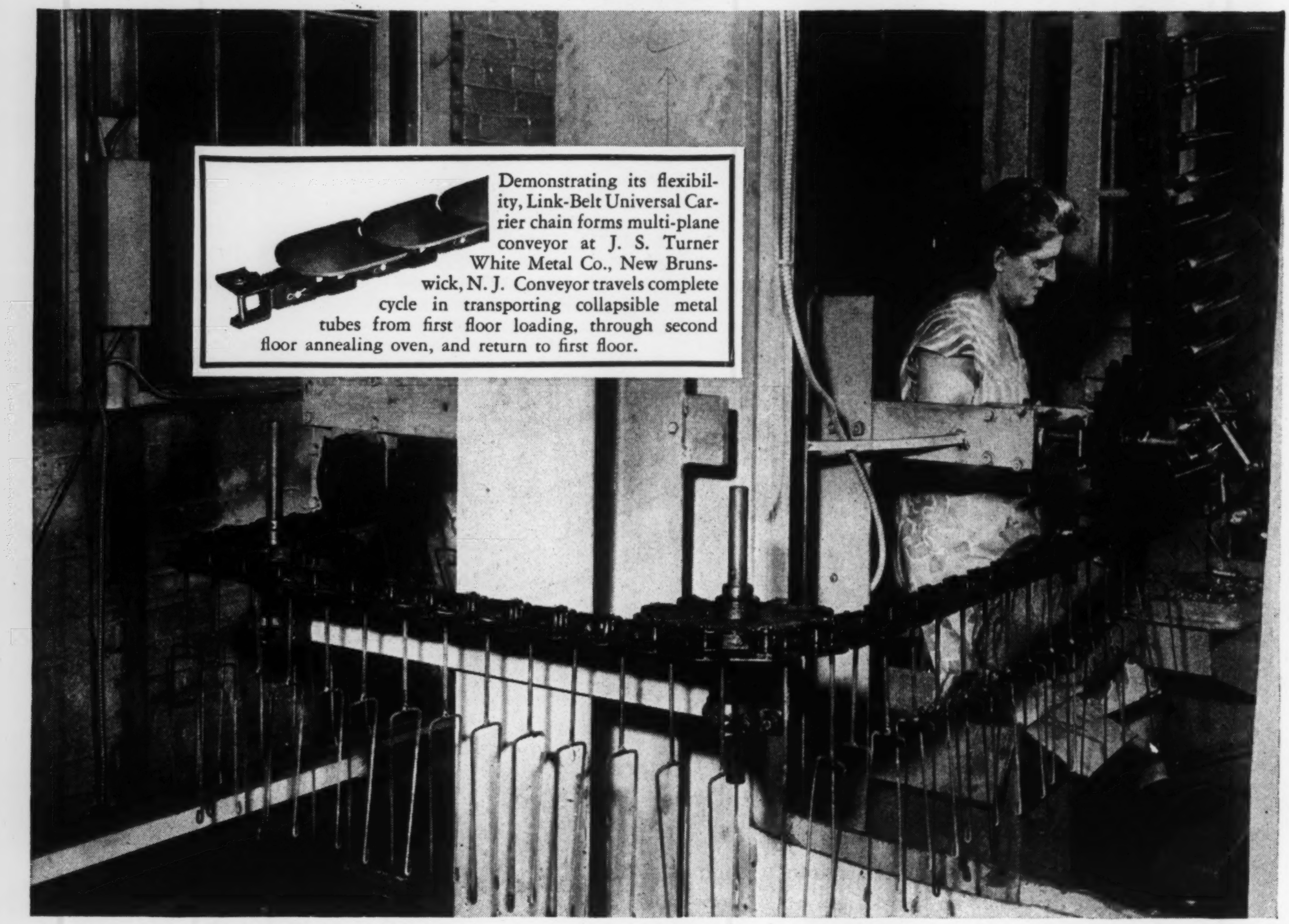
Thompson Products, Inc.

Cleveland 17, Ohio



12-pound, 65-HP Air-Turbine-driven Pump

Is there ONE chain that best meets your drive or conveyor problem?



Demonstrating its flexibility, Link-Belt Universal Carrier chain forms multi-plane conveyor at J. S. Turner White Metal Co., New Brunswick, N. J. Conveyor travels complete cycle in transporting collapsible metal tubes from first floor loading, through second floor annealing oven, and return to first floor.

You'll find the answer in LINK-BELT's complete chain line... a size and type for every job

The application shown above is an example of how you can select the *one* chain best suited for a particular need from the complete Link-Belt line. And each chain is engineered to provide more efficient service at lower cost than so-called general purpose chain.

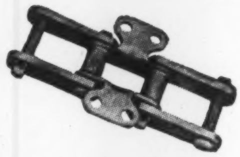
Whatever your requirements, you are assured of the *right* chain for the job when you rely on Link-Belt. And, remember—a chain bearing the Link-Belt double >——< arrow is your guarantee of longer chain life.

For information on the complete Link-Belt chain line, see the Link-Belt representative near you. He has the answers for efficient, low-cost drive and conveying chain performance.

LINK-BELT

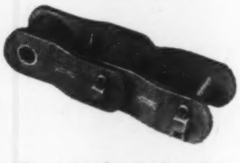
CHAINS AND SPROCKETS

Typical chains from the complete LINK-BELT line

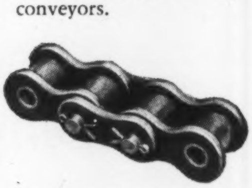


Class C combination chain — popular, durable, low cost design for elevators, conveyors.

Class 400 Pintle Chain — Closed end design keeps out dirt, makes excellent service medium for drives, elevators, conveyors.

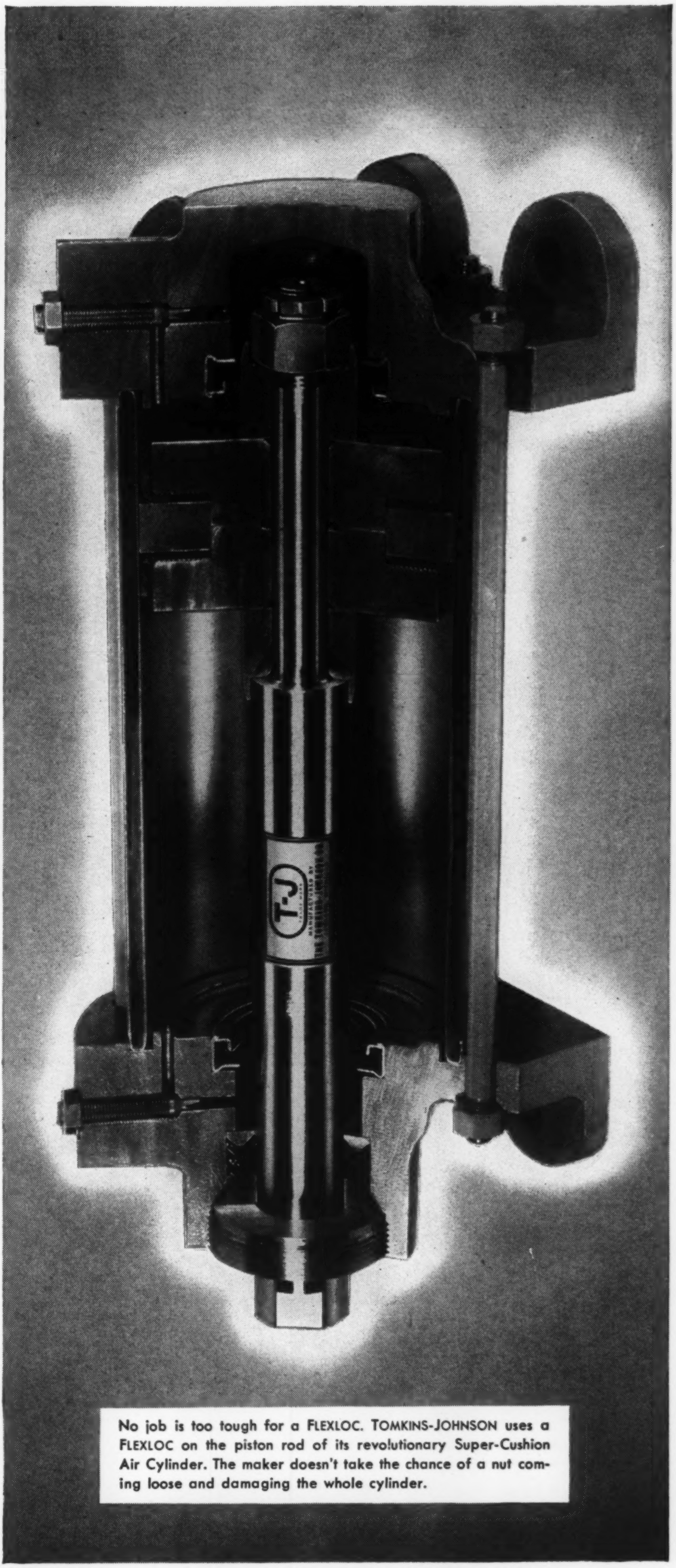


Class SS bushed roller chain with offset sidebars — for heavy drive service at moderate speeds.

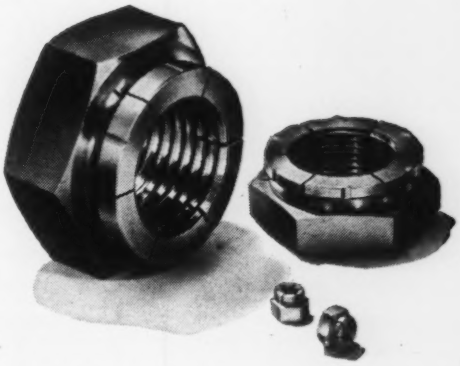


Link-Belt Precision Steel Roller Chain, standard pitch, for high-speed drives or conveyors.

LINK-BELT COMPANY: Plants: Chicago, Indianapolis, Philadelphia, Colmar, Pa., Atlanta, Houston, Minneapolis, San Francisco, Los Angeles, Seattle, Toronto, Springs (South Africa), Sydney (Australia). Sales Offices, Factory Branch Stores and Distributors in Principal Cities. 13,181-B



No job is too tough for a FLEXLOC. TOMKINS-JOHNSON uses a FLEXLOC on the piston rod of its revolutionary Super-Cushion Air Cylinder. The maker doesn't take the chance of a nut coming loose and damaging the whole cylinder.



What FLEXLOC locknuts do for you

FLEXLOCS eliminate complicated, time-consuming methods of locking threaded fasteners. They offer simpler, faster application and safer, more dependable locking than plain nuts and lockwashers, castellated nuts and cotter pins, or nuts and jam nuts. And they won't work loose.

The reasons for all this are plain. FLEXLOCS are one piece—nothing to assemble, come apart, lose or forget. FLEXLOCS are all metal—have higher tensile than most other locknuts and are not affected by temperatures to 550°F. FLEXLOCS are both stop and locknuts—don't have to seat to lock, and stay put anywhere on a threaded member as soon as their locking threads are fully engaged.

SPS can deliver any quantity of FLEXLOCS in a wide range of sizes. Stocks are carried by industrial distributors everywhere. Write for literature. SPS, Jenkintown 18, Pa.

FLEXLOC®
LOCKNUT DIVISION

SPS
JENKINTOWN PENNSYLVANIA

Our Fiftieth Year : A START FOR THE FUTURE

AUTOMOTIVE GEAR WORKS
GENERAL MANAGER
AUTOMOTIVE GEAR WORKS, INC.

"...and that is our Gear Department"

WE DOUBT that the photo of our plant hangs on many of our customers' walls. But we *do* serve as the "gear department" for many companies with both small and large gear requirements.

The benefits these customers enjoy might interest you. Working closely with you, all our facilities and personnel are at your service—trouble-shooting, designing, specifying, engineering, and manufacturing gears to meet your needs exactly. And behind these functions is the experience we have gained through almost forty years devoted exclusively to gear manufacture.

Of course, we sell to many manufacturers who make a portion of their own gear requirements, and shall always continue to do so. But for many companies, and perhaps yours is one, much may be gained by examining case histories of customers who refer to our company as their "gear department."

⁂

Write for our comprehensive catalog containing full information on the ten gear types in which we specialize.

AUTOMOTIVE GEAR WORKS, INC.

AUTOMOTIVE GEAR WORKS, INC.

RICHMOND, INDIANA

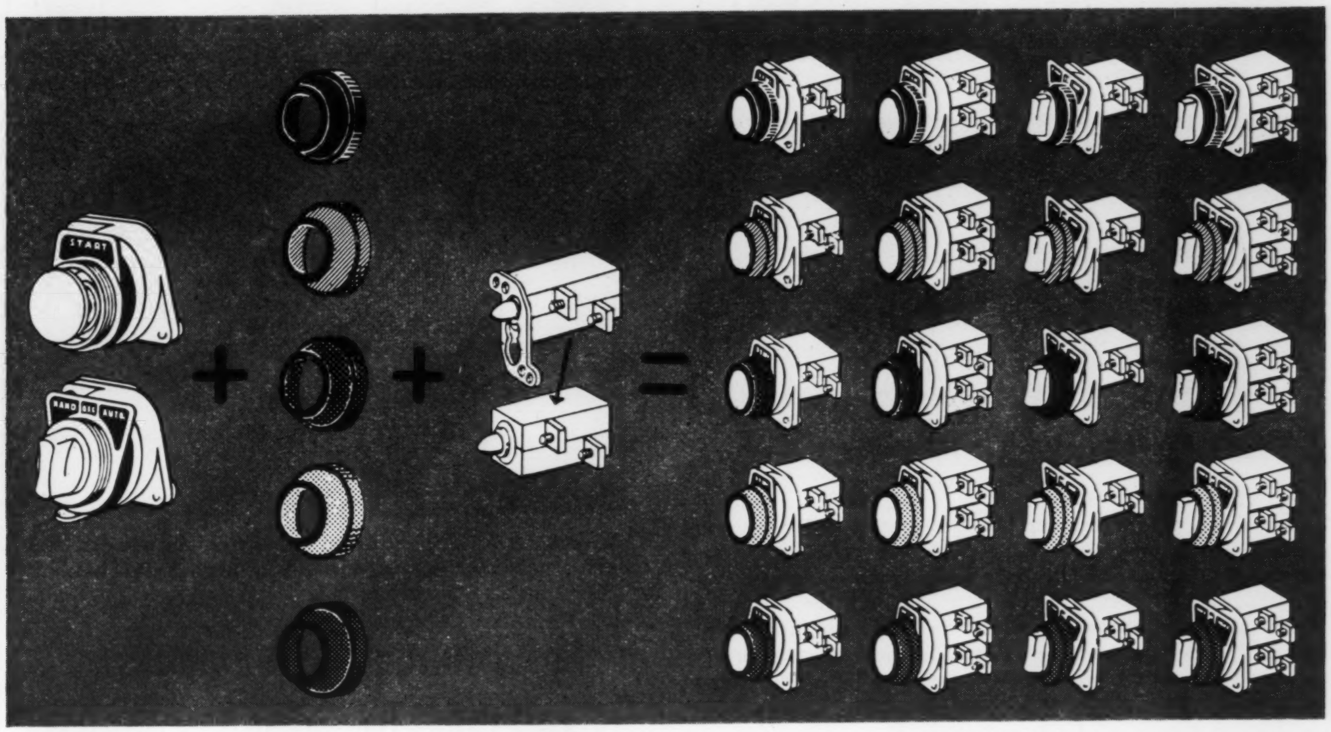
DOUBLE DIAMOND GEARS
TRADE MARK

FOR FARM EQUIPMENT, AUTOMOTIVE & GENERAL INDUSTRIAL APPLICATIONS

Digest

MOTOR & CONTROL HIGHLIGHTS

Stock only 9 parts, get 20 combinations with new G-E oiltight push-button line



Extra flexibility cuts your inventory cost

Especially designed to meet the needs of machinery designers and manufacturers, General Electric's all-new oiltight push-button line brings you new "building-block" flexibility—for new savings in assembly time, inventory costs, and storage space. For example, by stocking only two operators, five color-coding rings, and two contact blocks, you make 20 different push-button unit combinations. Standard components include one basic type of contact block, five interchangeable color rings for coding, and a wide variety of interchangeable operators.

Unit components, units, enclosures, or complete stations are all available in this new, out-in-front G-E line. For more information, make a note to see your G-E Apparatus Sales representative, or send for new Bulletin GEA-5779.

General Electric Company
Apparatus Sales Division, Sec. D668-102
Schenectady 5, N. Y.

1878 75 1953 YEARS OF ELECTRICAL PROGRESS

Please send me the following bulletins:

√ for reference purposes
× for immediate project.

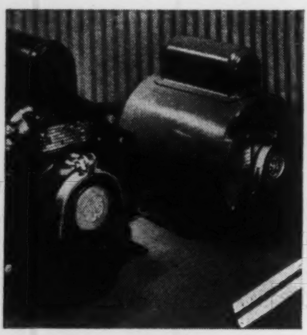
☐ **GEA-4400 Totally Enclosed Motors**
☐ **GEA-5779 Oil-tight Push-button Units**

CONSULT YOUR McGRAW-HILL ELECTRICAL CATALOG FOR PRODUCT ENGINEERS! You'll find "everything electric" for machinery manufacturers in the General Electric section.

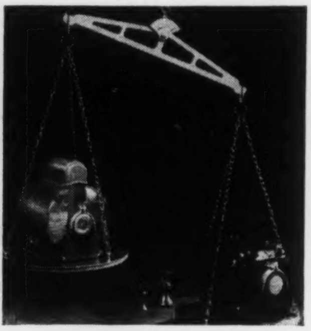
NAME ____________________
COMPANY ____________________
STREET ____________________
CITY ____________________ STATE ________

TURN PAGE FOR MORE G-E PRODUCT HIGHLIGHTS

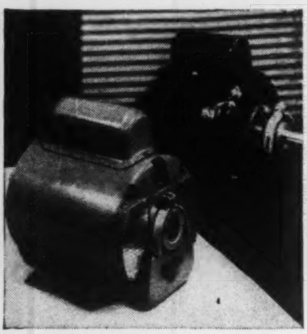
NEW G-E FHP MOTOR OFFERS FOUR BIG FEATURES TO IMPROVE YOUR PRODUCT



It's smaller . . .



lighter . . .

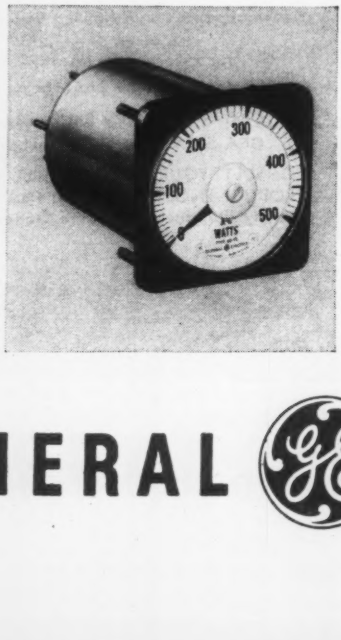


better looking . . .

more versatile!

You'll find this completely new line of G-E Form G fractional-horsepower motors can help you design new and more saleable features into your product; can free you from former design limitations. Smaller size saves space on driven machines. Lighter weight cuts your shipping and handling costs. Its better appearance aids your product's sales appeal. And all-angle operation means this standard, general-purpose motor can often replace costly specials. For complete information, see Bulletin GEA-5567.

SHADOWS ELIMINATED ON NEW G-E LONG-SCALE SWITCHBOARD INSTRUMENTS



New G-E shadow-proof design means accurate readings, even under sharp-angle lighting. Also, small size reduces mounting problems. Available as ammeters, voltmeters, and watt-meters, for either a-c or d-c. The AB-, DB-16 types feature an eight-inch diameter scale. The AB-, DB-18 types have a four-inch diameter scale. All are accurate within ± 1% of full scale. Check Bulletin GEC-218.

"Require less space, cut fabrication costs," says one oven manufacturer of the fin Calrod heaters he uses.

Calrod immersion heaters give these hospital sterilizers precision heat, withstand continuous wear.

Build-in Calrod* heaters . . . reliable, accurate, compact

When your products need clean, accurate, easily controlled heat, build-in General Electric Calrod heaters. Reliable, compact, and convenient, these heaters are quickly installed, require practically no maintenance.

Whatever machines *you* build that need a "spot" or "zone" of heat—packaging, textile, printing, bottling, labeling, or extrusion machines—there's an economical Calrod heater for the application. The full line includes immersion, strip, cartridge, tubular, and unit and fin heaters. See new illustrated 16-page Bulletin GEA-5866. It shows how 18 machinery manufacturers use Calrod heaters to improve their products. Check coupon at right for your copy.

**Reg. trade-mark of General Electric Company*

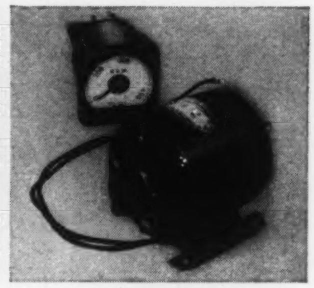
GENERAL ELECTRIC

Designer's Digest

PRODUCT HIGHLIGHTS

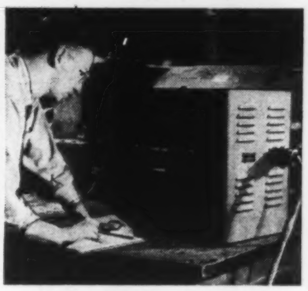
WIDE G-E TACHOMETER LINE PERMITS MEASURING RPM OF ANY MACHINE

Hand



Electric

Electronic

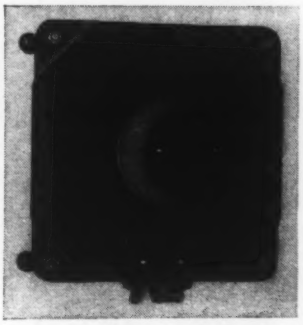


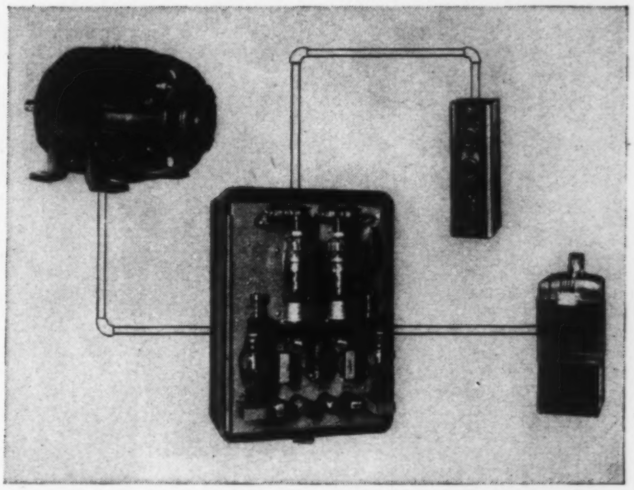
Special

Protect your product's quality from harmful changes in machine speed with one of these four G-E tachometer equipments. Use them, too, for checking the efficiency of your high-speed machines—to save fuel costs and save maintenance time. Accuracies vary from ±1 per cent to 0.025 per cent, covering ranges from 0 to 400,000 rpm. For full information, check appropriate bulletin in coupon.

EASY-TO-MOUNT PLATE RHEOSTATS GIVE CLOSE D-C SPEED CONTROL

For accurate d-c motor speed control, specify these G-E plate-type field rheostats. Four-point mounting eliminates need for additional feet or brackets. Adjustable stops at each end of travel, give added flexibility. Three sizes: 12-inch with 70 resistance steps, 9-inch with 52 steps, 6-inch with 27 steps. See Bulletin GEC-487.





Now—a simplified, smaller G-E adjustable-speed drive

All the basic features of General Electric's Thy-mo-trol* adjustable-speed drive—smooth, stepless speed control, pre-set speed control, and close speed regulation—are included in this new, lower-cost, standardized model. Simplified, space-saving electronic control panel (also supplied in open form) is half the size of more elaborate types. In reversing and non-reversing forms, ratings are ¾, 1, 1½, 2, and 3 hp, in speed ranges of 5:1 and 20:1 (1750/350 rpm and 1750/88 rpm.)

For complete data on the ¾ to 3 hp drive—part of the full Thy-mo-trol line ranging from 1/40 to 75 hp—see Bulletin GEA-5829.

General Electric Company,
Apparatus Sales Division, Sect. D668-103
Schenectady 5, N. Y.

1878 75 1953
YEARS OF ELECTRICAL PROGRESS

Please send me the following bulletins:

√ for reference purposes X for immediate projects

- ☐ GEA-4324 Electric tachometers
- ☐ GEA-5567 Fhp motors
- ☐ GEA-5829 ¾—3 hp Thy-mo-trol
- ☐ GEA-5866 Calrod heaters
- ☐ GEC-218 Switchboard instruments
- ☐ GEC-224 Electronic tachometers
- ☐ GEC-241 Hand tachometers
- ☐ GEC-487 Plate rheostats
- ☐ GEC-560 Special tachometers

CONSULT YOUR McGRAW-HILL ELECTRICAL CATALOG FOR PRODUCT ENGINEERS! You'll find "everything electric" for machinery manufacturers in the General Electric section.

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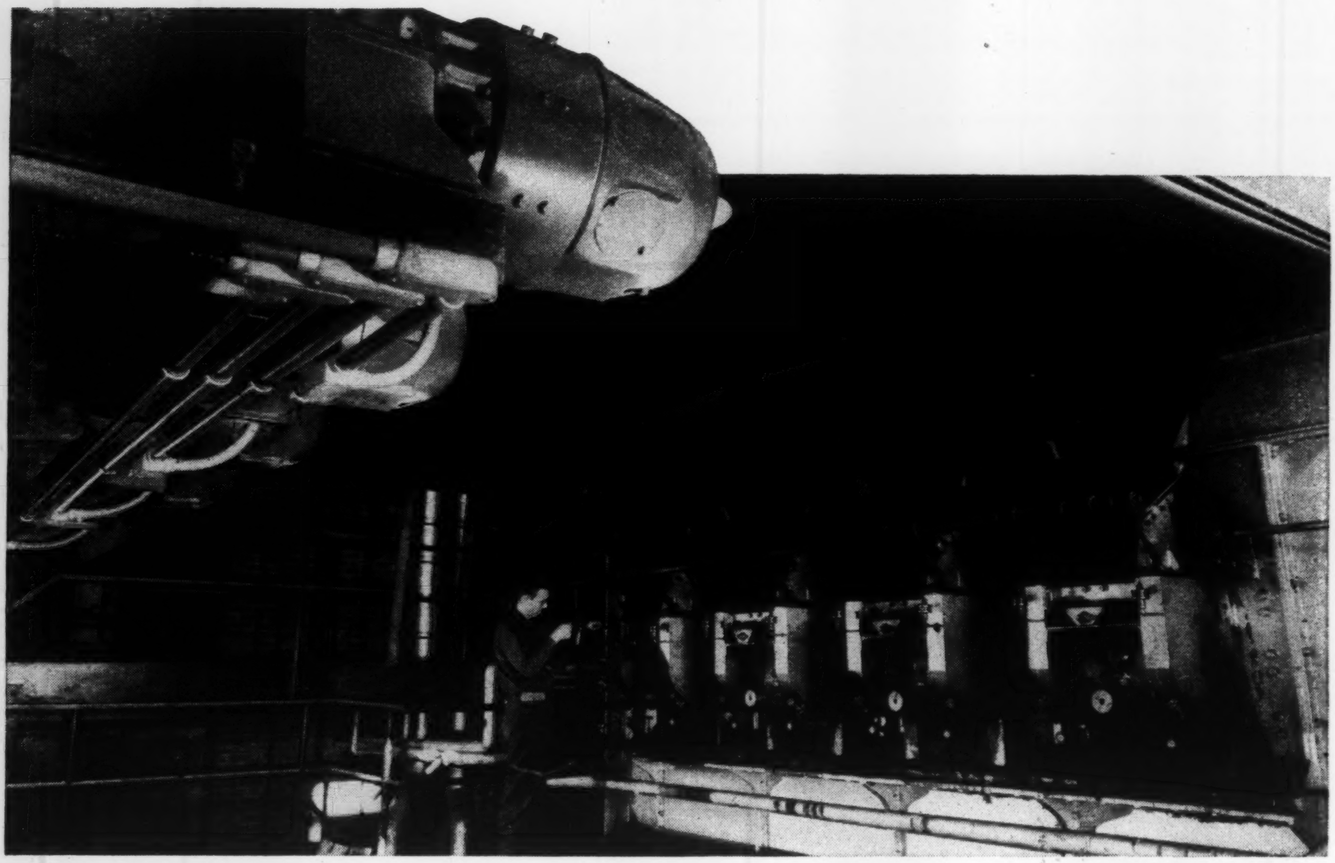
STREET ____________________

CITY ____________________ STATE ________



Drive mounting problems erased with Westinghouse *Life-Line** Gearmotors

Putting the best drive in the minimum space is a problem constantly facing design engineers. In answer to this problem, Westinghouse Life-Line Gearmotors provide unit compactness, rugged construction and job-proved efficiency.

Westinghouse Life-Line Gearmotors have both motor and gears designed as an integral unit. As a result, there's a major saving in space because all belts, chains and pulleys can be eliminated. This means no alignment problems. Since integral design lessens the number of wearing parts, over-all maintenance is cut to a minimum.

With split-case gearmotors, there's no need to allow large work areas for removal or dismantling—all servicing can be done with the gearmotor "on the job". Split-case construction permits the gear cover to be removed in minutes and makes all working parts readily accessible. Any servicing, therefore, becomes a simple, speedy operation.

Taper-hardened gear teeth, thorough lubrication and industry-tested Life-Line Motors are but a few of the features which assure long, dependable performance from Westinghouse Gearmotors.

Your local Westinghouse Representative will gladly furnish you with additional information. Call him at any time or write Westinghouse Electric Corporation, P. O. Box 868, Pittsburgh 30, Pa.

*Trade-Mark J-07322

YOU CAN BE *SURE*...IF IT'S
Westinghouse

RESEARCH KEEPS **B.F.Goodrich** FIRST IN RUBBER

New sealing zipper zips to seal out gas, liquids, dirt . . . unzips to let you in

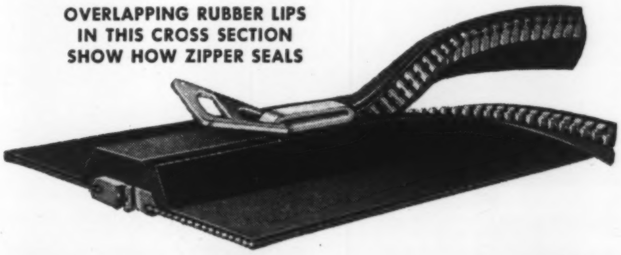
HERE'S A NEW KIND OF SEAL that shuts out liquids, gas, dirt—yet zips open in seconds. It's the B. F. Goodrich Sealing Zipper.

It is made with molded rubber lips that overlap with such precision that they seal *tight,* even without pressure. Under pressure, the seal actually tightens. The only limit on the pressure, in fact, is the structural strength of the zipper itself!

This seal is so flexible, it goes around curves and odd shapes where clamps won't work. Repairs are faster because zipper halves are interchangeable. It can be made of compounds to resist weather, oils, gasoline, chemicals. It can be sewn or cemented to metal, wood, glass. The rubber can be made to match any color.

In the picture, the B. F. Goodrich Sealing Zipper fastens the rear window of a convertible auto to the fabric top. It offers the first *complete* protection to keep weather stains and mildew from the inside fabric. It gives neater, tailored styling. Color matches, inside and out. And it cuts production costs, because it is so easy to install. It is now standard on three makes of convertibles.

The BFG Sealing Zipper is ideal for any use that combines a need for an airtight, watertight barrier with ease of opening. It has been proved in dozens of applications for aviation and transportation fields. Write Dept. A-32 for complete information, or send coupon below. The B. F. Goodrich Company, Zipper Division, Akron, Ohio.



OVERLAPPING RUBBER LIPS IN THIS CROSS SECTION SHOW HOW ZIPPER SEALS

B.F.Goodrich

Airtight, Watertight Sealing Zipper

SEND NOW FOR FREE FOLDER

Gives case histories, design advantages, suggested uses.

The B. F. Goodrich Company
Dept. A-32, Akron 18, Ohio

Name ____________________

Company ____________________ Title __________

Address ____________________

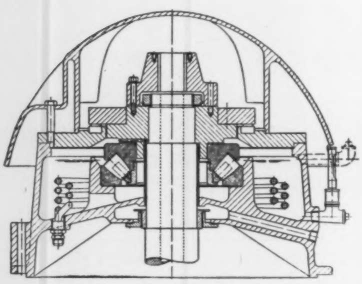
City ____________________ Zone ____ State __________

Highest anti-friction capacity for VERTICAL SHAFT applications

The SKF Spherical Roller Thrust Bearing is becoming more and more popular as the means of supporting heavy thrust loads at high speeds. Vertical shaft applications demand bearing engineering which is abreast of the newest developments in equipment design.

Here is *why* the SKF Spherical Roller Thrust Bearing is earning increased application with manufacturers everywhere:

- The bearing has very high capacity for thrust loads, and combined loads which are predominantly thrust.
- It is fully self-aligning—has a single row of rollers which roll on a spherical outer race with full self-alignment.
- The bearing design is such that the lubricant is pumped outwardly against the inner ring high guide flange — thereby insuring perfect lubrication and long, trouble-free life.

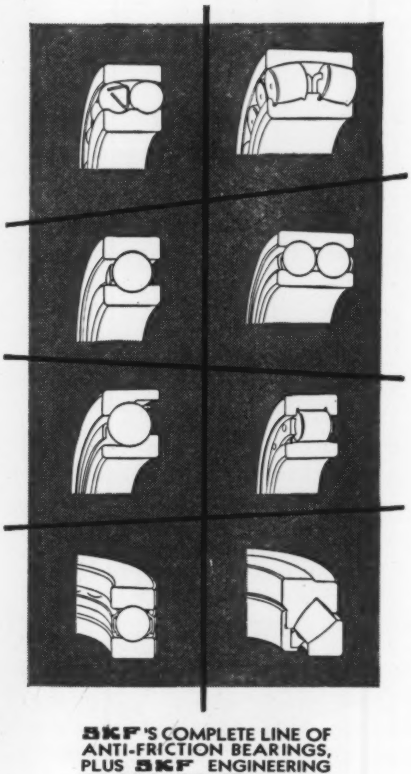


The drawing shows a typical application of the SKF Spherical Roller Thrust Bearing—providing higher *capacity*, size for size, than any available design.

When you're laying-in anti-friction bearings, you can get design assistance and help from SKF Field or Home Office men who know the best ways to do the job in every industry. And, when you have a bearing replacement to make, call your SKF Distributor. 7435

SKF INDUSTRIES, INC., PHILA. 32, PA.,—*manufacturers of* **SKF** *and* HESS-BRIGHT *bearings.*

SKF
BALL AND ROLLER BEARINGS

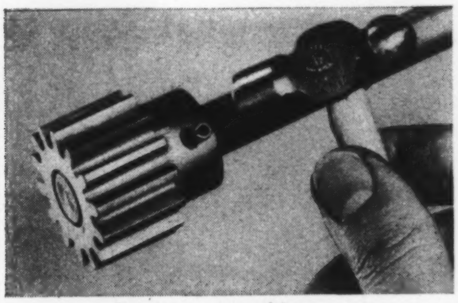


SKF'S COMPLETE LINE OF ANTI-FRICTION BEARINGS, PLUS **SKF** ENGINEERING CO-OPERATION, HELPS YOU *PUT THE RIGHT BEARING IN THE RIGHT PLACE.*

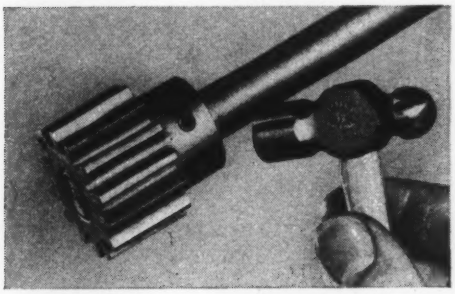
Where can you use this simple fastener?

No threading, peening or precision drilling with ROLLPIN

Rollpin is driven into holes drilled to normal production-line tolerances.



It compresses as driven.



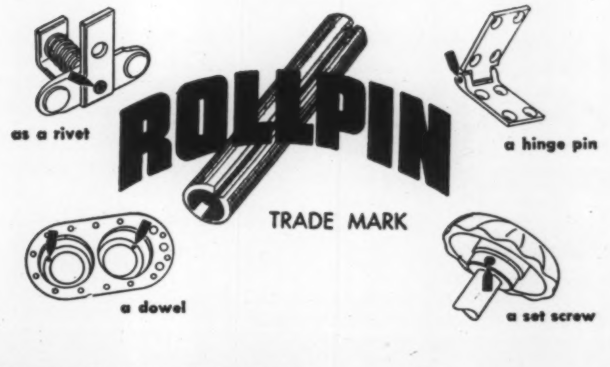
Rollpin fits flush . . . is vibration-proof.

Rollpin is the slotted tubular steel pin with chamfered ends that is cutting production and maintenance costs in every class of industry.

This modern fastener drives easily into standard holes, compressing as driven. Its spring action locks it in place—regardless of impact loading, stress reversals or severe vibration. Rollpin is readily removable and can be re-used in the same hole.

* * *

If you use locating dowels, hinge pins, rivets, set screws—or straight, knurled, tapered or cotter type pins—Rollpin can cut your costs. Mail our coupon for design information.



Elastic Stop Nut Corporation of America
Dept. R16-64, 2330 Vauxhall Road, Union, N. J.
Please send me the following free fastening information:

☐ Rollpin bulletin

☐ Elastic Stop Nut bulletin

☐ Here is a drawing of our product. What fastener would you suggest?

Name__________ Title__________

Firm__________

Street__________

City__________ Zone_____ State_____

STOP CORROSION
with corrosion resistant fastenings by
1¼"-7 MONEL NUT
¾"-10 SILICON BRONZE FULL NUT
¾"-10 SILICON BRONZE JAM NUT
SPECIALISTS IN CORROSION RESISTANT FASTENINGS

HARPER

The cancer of corrosion is constantly at work, eating away the life of the equipment you manufacture. The H. M. Harper Company specializes in "Everlasting Fastenings" to combat corrosion. Bolts—nuts—screws—rivets—studs—washers of brass—naval bronze—silicon bronze—Monel—nickel—copper—aluminum—stainless steel—and the newer high temperature alloys.

Skilled engineers and metallurgists, backed by 30 years of experience, are available to work with you on the design and production of fastenings to solve the tough corrosion and assembly problems you may be facing.

In every market area, you will find Harper Branch Offices and Distributors ready to give you prompt service. Over 7,000 items are carried in stock, making it possible for you to fill all your requirements from one source, bringing you these advantages—one order to write—one account to keep—one bill to pay.

THE H. M. HARPER COMPANY
8202 Lehigh Ave., Morton Grove, Ill.

HARPER
EVERLASTING FASTENINGS

BRASS • SILICON BRONZE • NAVAL BRONZE • MONEL • NICKEL • COPPER • ALUMINUM • STAINLESS STEEL

Custom made for your forging job

Another reason why you get uniform, high quality forgings with TIMKEN® forging steels!

YOUR order for Timken® forging steels is handled individually in our mills. Conditioning procedure is targeted to your particular forging requirements. You get just the steel you want for uniform forgings, rejects are held to a minimum. And you save steel, because the good dimensional tolerances of Timken steel forging bars produce uniform weight multiples with minimum steel lost in flashings.

Timken forging steels give you uniform physical properties. They respond uniformly to heat treatment—from bar to bar and heat to heat. Fewer furnace adjustments are needed. And Timken forging steels have uniform grain size after heat treatment. Result: your forgings have uniformly high ductility and resistance to impact.

Chemical properties, too, are kept uniform in every lot of Timken forging steels by some of the most precise quality control methods known. For example, a direct-reading spectrometer—first of its kind in the steel industry—chemically analyzes a molten heat of Timken forging steel in just 40 seconds! And the melt shop has the complete analysis report within 10 minutes!

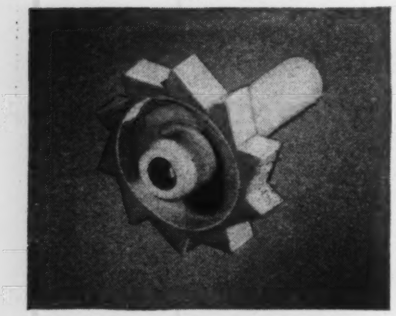
For help in improving the quality of your forgings, and cutting production costs, too, write The Timken Roller Bearing Company, Steel and Tube Division, Canton 6, Ohio. Cable address: "TIMROSCO".

YEARS AHEAD—THROUGH EXPERIENCE AND RESEARCH

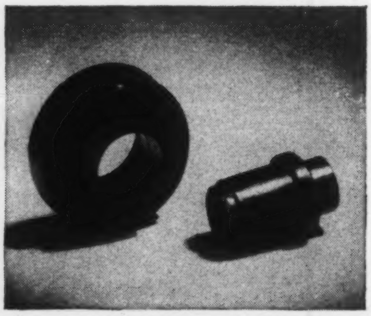
TIMKEN
TRADE-MARK REG. U.S. PAT. OFF.
Fine Alloy
STEEL

SPECIALISTS IN FINE ALLOY STEELS, GRAPHITIC TOOL STEELS AND SEAMLESS TUBING

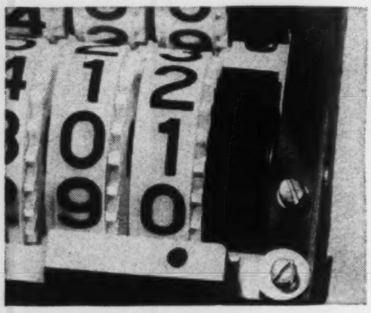
54 parts in this



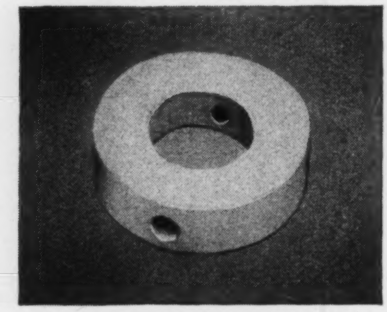
NYLON STARWHEEL is molded in one piece . . . *simplifies design* . . . saves manufacturing steps.



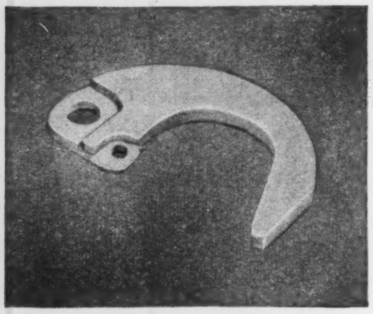
NYLON ASSEMBLY has *excellent bearing characteristics* . . . low coefficient of friction.



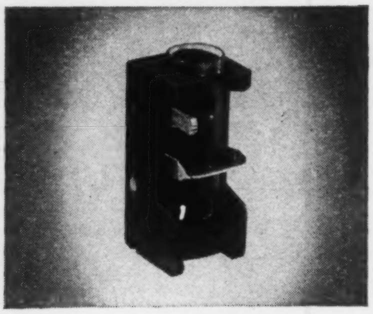
NYLON RATCHETS that control counter wheels are *lightweight*. . . combat inertia . . . guarantee accurate operation.



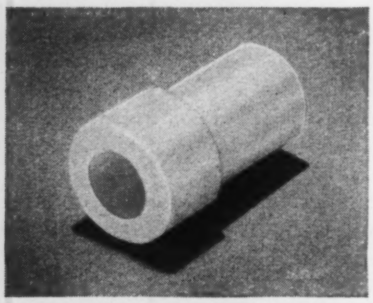
NYLON WHEEL is *strong, tough, dimensionally stable* . . . may be dyed for assembly identification.



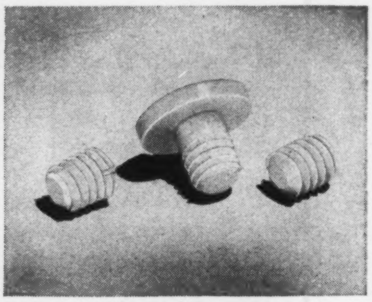
NYLON SHAFT LOCK is *molded to close tolerances* . . . finishing operations are minimized or eliminated.



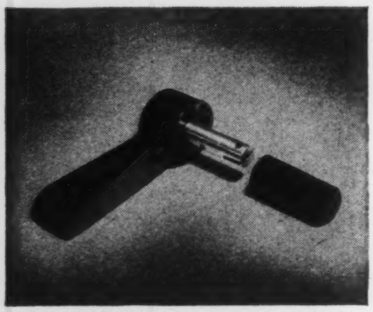
NYLON CHANGE CARRIER is *virtually unbreakable*. . . cuts weight . . . gives positive action in dispensing coins.



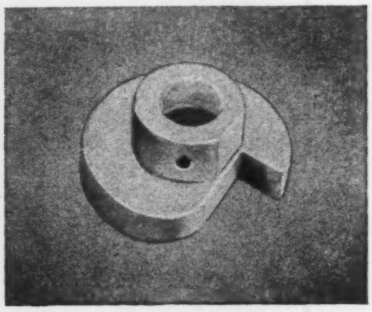
NYLON BEARINGS *need no lubrication* after installation . . . operate quietly . . . give long, dependable service.



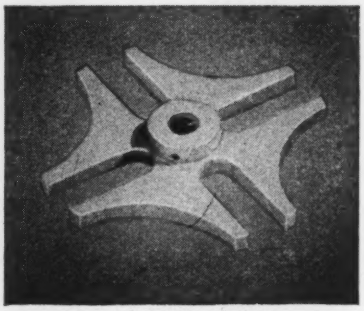
NYLON SCREWS are *resilient* . . . have "self-locking" properties . . . hold settings over long periods.



NYLON KNOBS are *smooth, tough*. . . pleasant to the touch . . . keep their newly finished appearance.

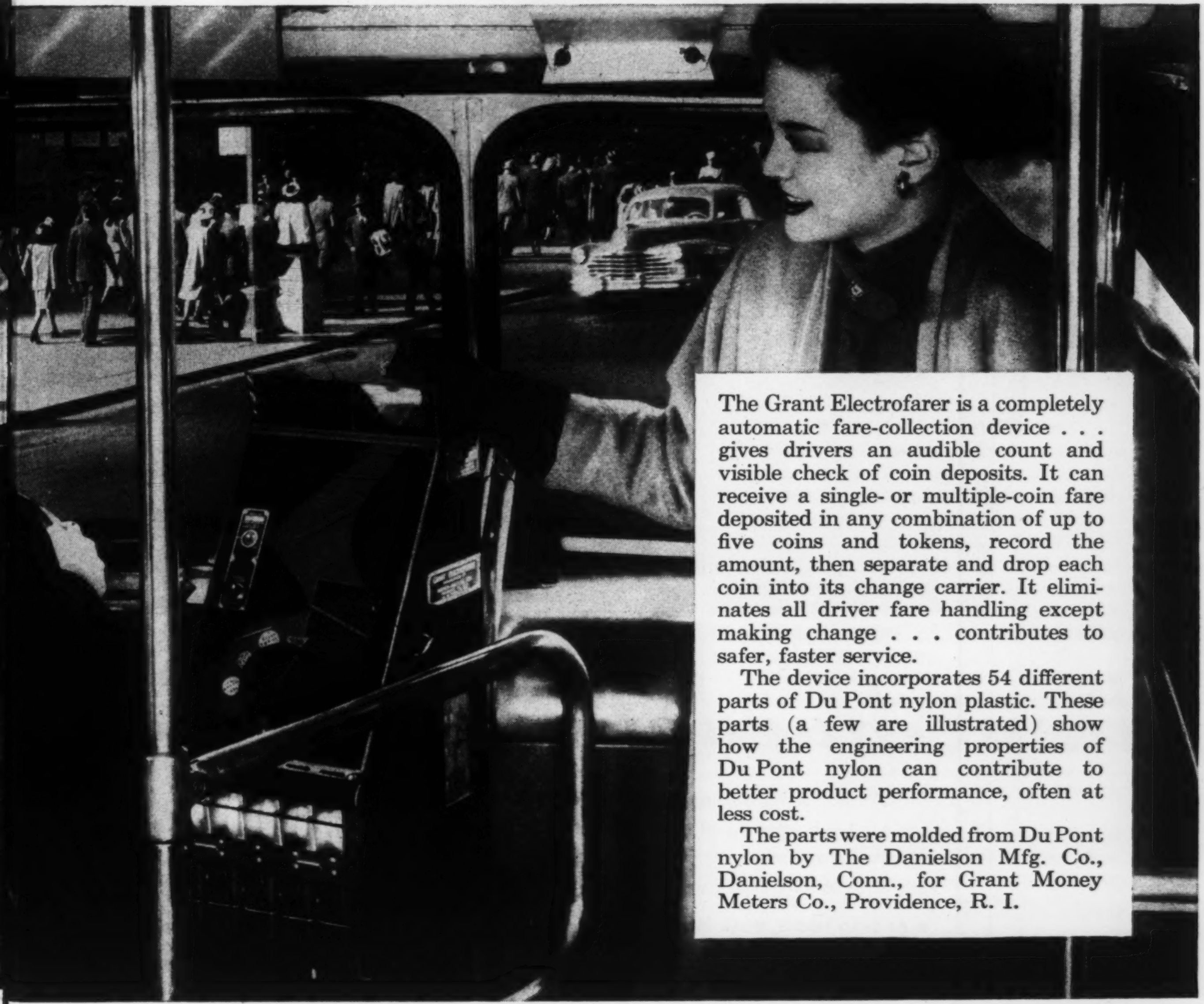


NYLON CAM *resists wear* . . . is strong, will not chip or crack . . . needs no lubrication.



NYLON GENEVA CAMS are *strong in thin sections* . . . *unaffected by corrosion* . . . cut manufacturing costs.

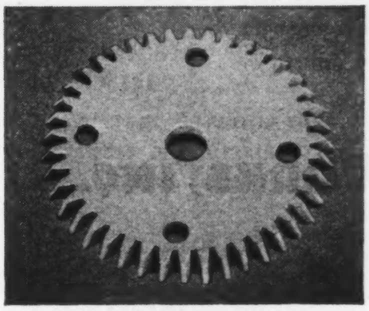
# of Du Pont nylon plastic new fare collector



The Grant Electrofarer is a completely automatic fare-collection device . . . gives drivers an audible count and visible check of coin deposits. It can receive a single- or multiple-coin fare deposited in any combination of up to five coins and tokens, record the amount, then separate and drop each coin into its change carrier. It eliminates all driver fare handling except making change . . . contributes to safer, faster service.

The device incorporates 54 different parts of Du Pont nylon plastic. These parts (a few are illustrated) show how the engineering properties of Du Pont nylon can contribute to better product performance, often at less cost.

The parts were molded from Du Pont nylon by The Danielson Mfg. Co., Danielson, Conn., for Grant Money Meters Co., Providence, R. I.



NYLON GEARScan *operate continuously to 250°F.* . . . are readily molded in one operation . . . cut costs.

Du Pont nylon parts can be economically mass-produced by injection molding . . . are light in weight . . . give better performance. Nylon molding powders are available in a number of compositions, each with different properties, for mechanical, electrical and other uses. For information, write: E. I. du Pont de Nemours & Co. (Inc.), Polychemicals Dept., Room 126 Du Pont Bldg., Wilmington, Delaware.

DU PONT

REG. U. S. PAT. OFF.

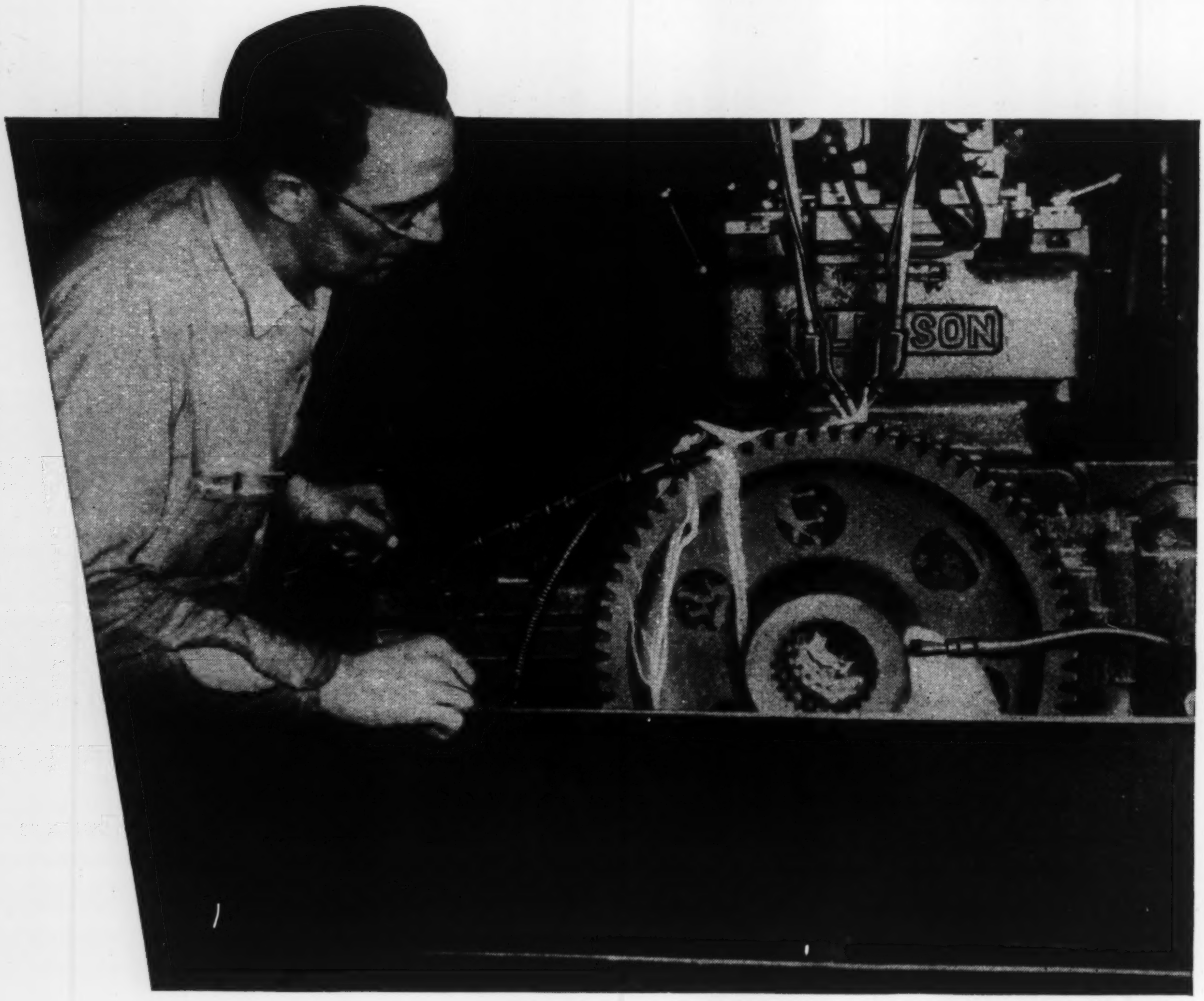
BETTER THINGS FOR BETTER LIVING

. . . *THROUGH CHEMISTRY*

Polychemicals

DEPARTMENT

PLASTICS • CHEMICALS



flame-hardening ✦ ✦ ✦

. . . a process for hardening ferrous metal surfaces.
It permits the hardening of gear teeth, thus increasing wearability,
while the gear body's ductility, toughness and
resistance to impact are undisturbed.

- At BRAD FOOTE, flame-hardening, and every other operation from design to shipment of finished gears, is done in our own plant—by our own skilled workers. No one shares our responsibility.
- When you order BRAD FOOTE gears, you know for sure they will give long, satisfactory service in your shop—or on the equipment you sell to others. BRAD FOOTE makes gears . . . good gears . . . for a world at work.

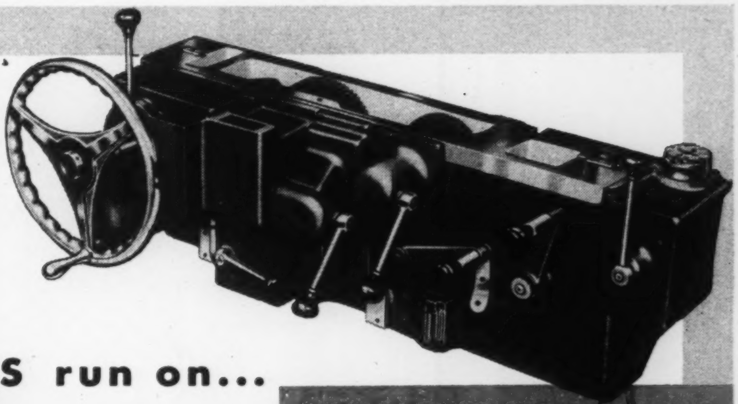
BRAD FOOTE GEAR WORKS, INC.

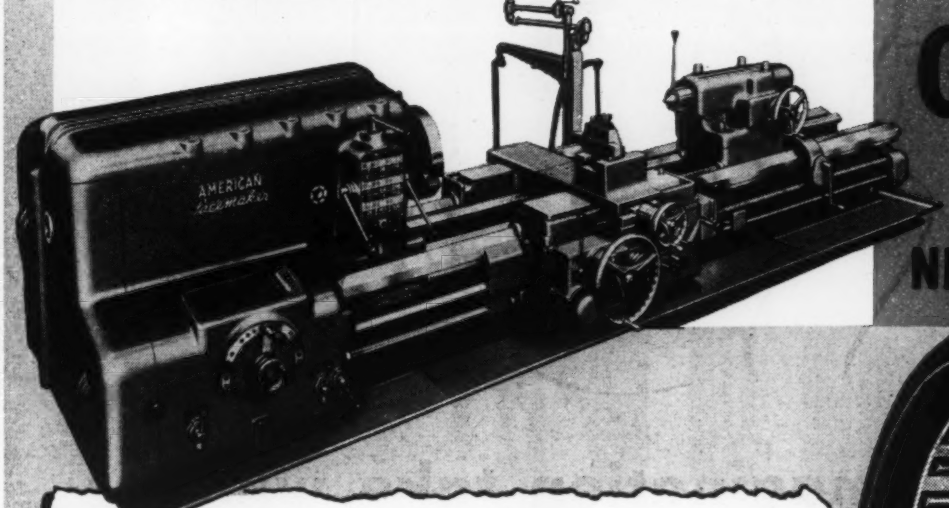
1309 South Cicero Avenue • Cicero 50, Illinois
BIshop 2-1070 • OLympic 2-7700

subsidiaries

AMERICAN GEAR & MFG. CO. • **PITTSBURGH GEAR COMPANY**
Phone: Lemont 920 — Phone: ATlantic 1-9950
Lemont, Illinois — Pittsburgh 22, Pennsylvania

Feed Pinions in Aprons
of 25" and 32"
AMERICAN
"PACEMAKER" LATHES run on...

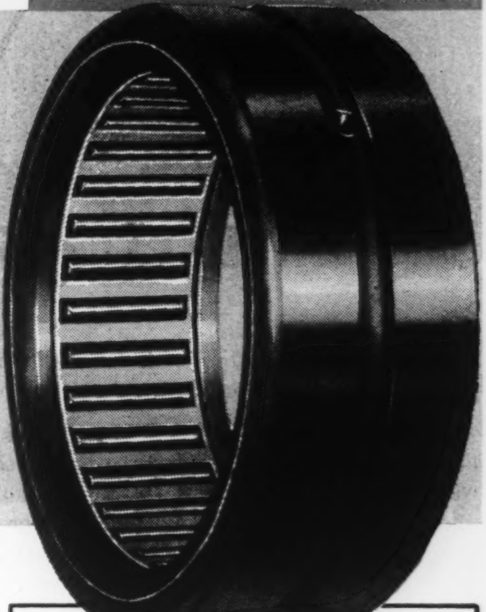




ORANGE
Cage Type
NEEDLE BEARINGS

"They are dependable, long-lived
and the cage design insures
perfect alignment of rollers".

— reports American Tool Works Company



Orange Cage Design prevents roller skewing

In Orange Cage Type Needle Bearings, the rollers are held in alignment by retaining pockets of an anti-friction, non-ferrous cage. The cage guides, but does not wear on rollers.

With roller skewing eliminated, Orange Cage Type Needle Bearings permit you to gain the high load capacity and space savings of needle bearings on many applications heretofore unsuited to conventional types.

The Orange cage design is time-proven—has been used successfully for years on numerous installations, in all types of well-known equipment. Investigate them for your own products.

Send for Engineering Data Book

TRUE RUNNING
IN ANY POSITION

—vertical, tilted, horizontal
—on overhung mountings
—at relatively high speeds

•

Less affected by misaligned mountings or uneven loading

ORANGE

ORANGE ROLLER BEARING CO., INC., 556 Main Street, Orange, N. J.

SUPER-FINE INSULATION
LOF
FIBER GLASS

Let your imagination take wings on L·O·F Super·Fine Fiber·Glass

Just a little imagination . . . that's all it takes, and you can find any number of practical uses for L·O·F Super·Fine Fiber·Glass to profit you and your product.

Starting with Fiber·Glass . . . millions of tiny glass fibers held together by special binders to form lightweight insulating blankets . . . designers and engineers uncovered countless applications. Here are a few: components for rockets, protective wraps for frozen food, blackboard erasers, thermal curtains for greenhouses and the list goes on and on.

Check the outstanding properties of Super·Fine Fiber·Glass, relate them to your problem and let your imagination take wings.

Deadens sound. L·O·F Super·Fine Fiber·Glass is excellent acoustical insulation for middle- and high-frequency sound levels. It is highly flexible and can be fitted to irregular contours and shapes.

Prevents heat transfer. Super·Fine is superior to any inorganic fibrous insulation in its resistance to heat flow. The glass fibers will not burn, absorb moisture, mildew or rot.

Light as a feather. One square foot of Super·Fine Fiber·Glass, of a ¾-pound density and one-inch thickness, weighs only one ounce. It is easily cut with scissors, knife or roller cutter.

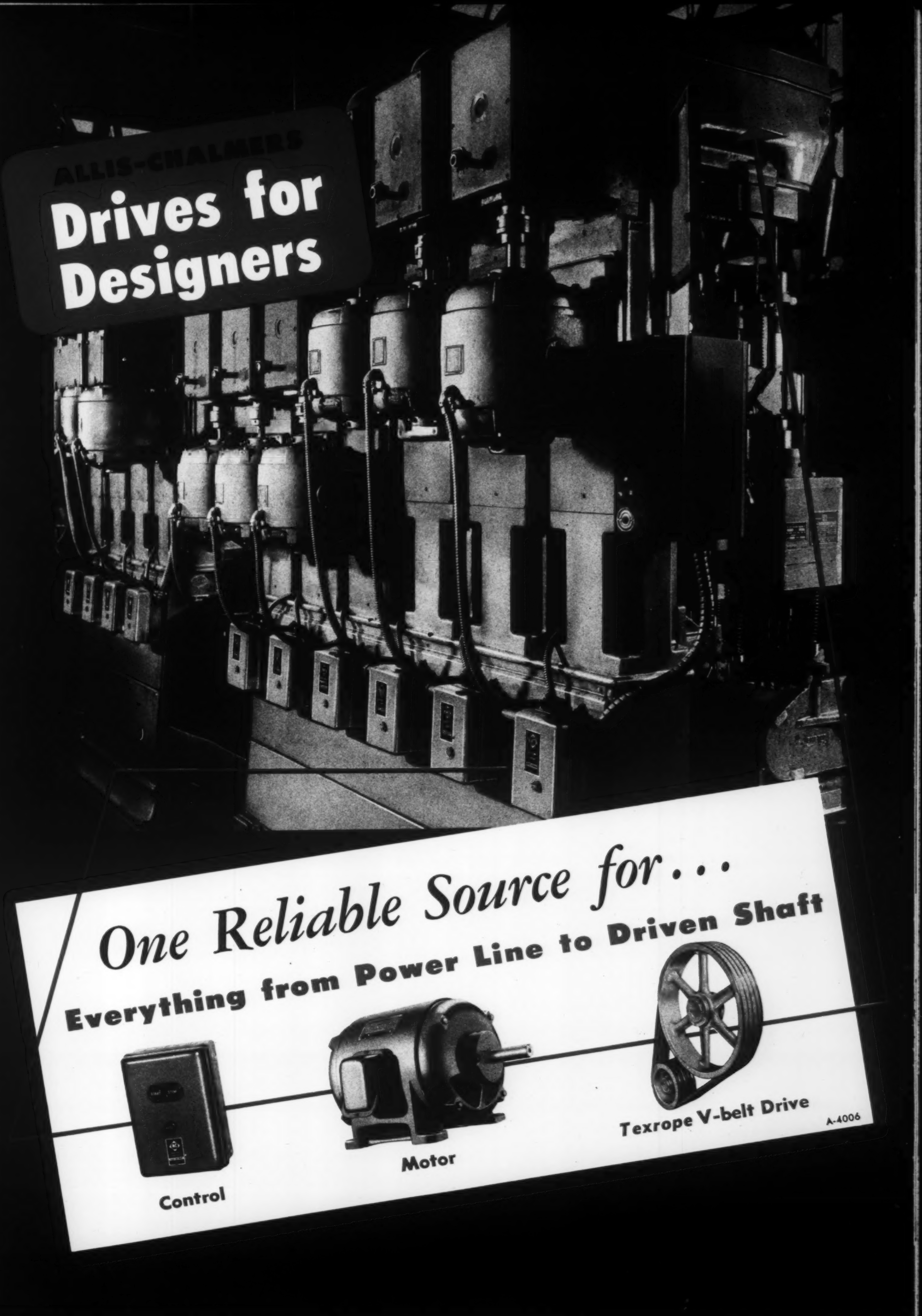
Supplied by a great name in glass. Libbey·Owens·Ford, long famous for outstanding glass products, assures you of top-quality Fiber·Glass delivered to your specifications right on schedule.

L·O·F Super·Fine Fiber·Glass can serve you or your product. Contact your nearest L·O·F office (offices in 26 major cities). Or write Libbey·Owens·Ford Glass Company, Fiber·Glass Division, 3663 Wayne Building, Toledo 3, Ohio.

LOF GLASS
LOF PLASKON
LOF FIBER·GLASS

LIBBEY·OWENS·FORD GLASS COMPANY
FIBER-GLASS DIVISION

FIBER·GLASS



ALLIS-CHALMERS

Drives for Designers

One Reliable Source for . . .

Everything from Power Line to Driven Shaft

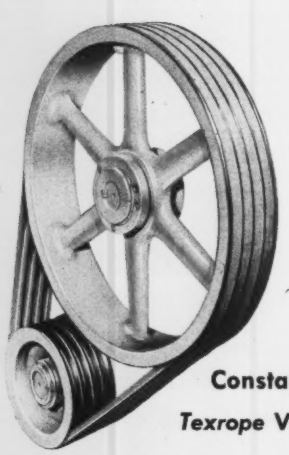
Control

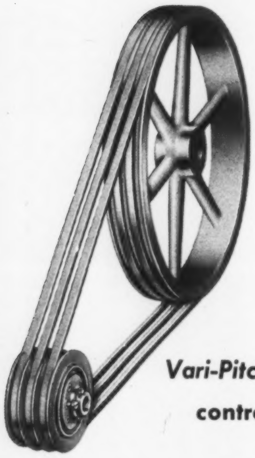
Motor

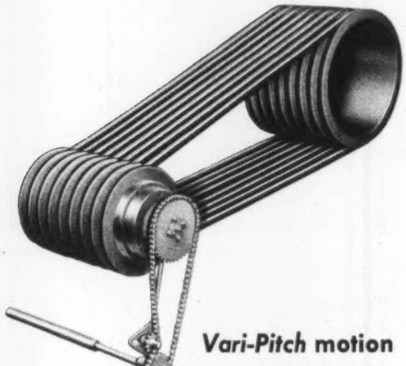
Texrope V-belt Drive

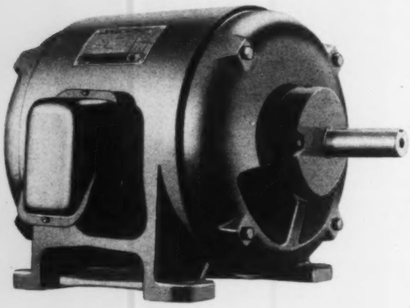
A-4006

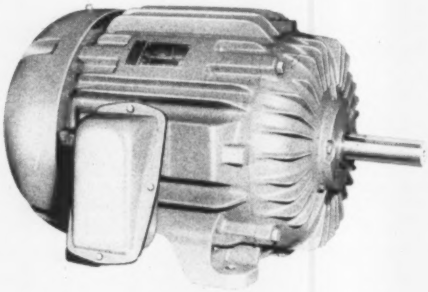
Designed to

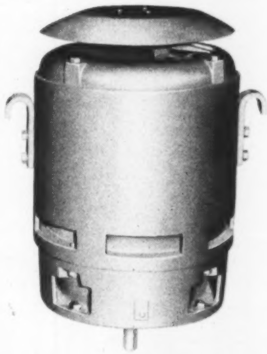

Constant speed
Texrope V-belt drive


Vari-Pitch stationary
control drive


Vari-Pitch motion
control drive


Open, drip-proof
squirrel cage motor


Totally-enclosed, fan-cooled
squirrel cage motor


Open, drip-proof, face-mounted
vertical squirrel cage motor

START
STOP
RESET
Across-the-line manual starter

Combination
starter

Reduced voltage starter

ALLIS-CHALMERS

Work Together

Texrope Drives

Texrope V-belt drives, the original multiple V-belt drive, are available in a complete range of sizes and types, both fixed and variable speed. More and more designers are finding that the moderate cost of *Vari-Pitch* sheaves is returned many times in increased machine versatility and more precise quality control. With either Stationary Control or Motion Control *Vari-Pitch* sheaves, speeds can be accurately adjusted quickly and easily over a wide range.

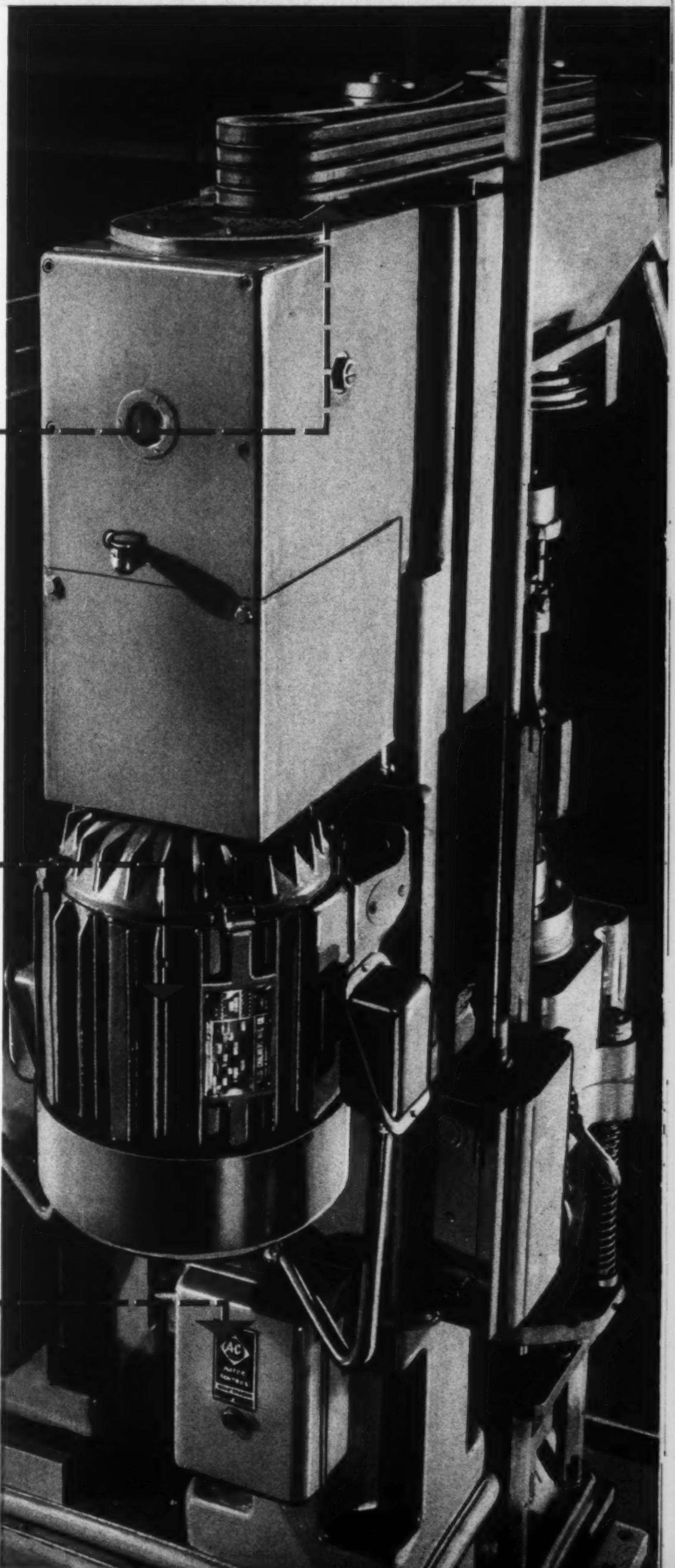
Texrope and Vari-Pitch are Allis-Chalmers trademarks.

Motors

Allis-Chalmers general purpose, special purpose and special design motors meet almost every designer's needs for motors from ½ hp up. Types include squirrel cage, wound rotor and dc for single or multi-speed operation. Available with a full range of torque characteristics and a wide option of enclosures and mounting methods. Special designs to meet any requirement. Shown at the right is a drilling machine equipped with a totally-enclosed, fan-cooled Allis-Chalmers motor. Reduced maintenance of the dirt-excluding fin-type design is making it very popular for machine tool applications.

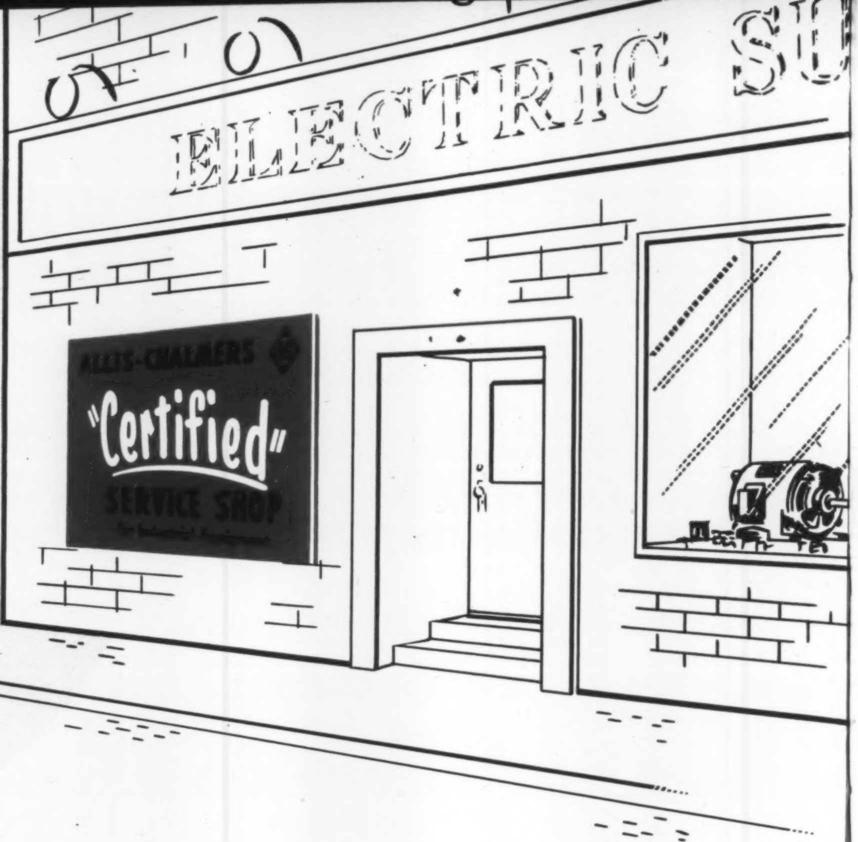
Motor Control

Allis-Chalmers motor control is available for most designers' applications from size 0 up. Allis-Chalmers builds many types of squirrel cage and wound rotor motor control, dc motor control, and variable speed control for many applications. Shown here is a full voltage across-the-line starter with reset button.



A-C
ALLIS-CHALMERS

Everything
from Power Line
to Driven Shaft



Nation Wide Service

YOUR CUSTOMERS will have no trouble getting competent service on your products when you use Allis-Chalmers motors, control and drives. There are nearly 100 Allis-Chalmers Certified Service Shops located in every industrial area in the country.

Allis-Chalmers Certified Service Shops are hand-picked independent units which have been chosen for their modern equipment, efficient methods, wide experience and business integrity. These Certified Service Shops assure your customers of factory-approved parts and service methods on Allis-Chalmers drive equipment. If you use special motors, the factory makes available to all Certified Service Shops the necessary information to assure a good service job.

ALLIS-CHALMERS A-C ALLIS-CHALMERS

Milwaukee 1, Wisconsin

SEND THIS COUPON TODAY

Allis-Chalmers Manufacturing Company
Box 512
Milwaukee 1, Wisconsin

Please send me the literature for designers checked below.

Motors

☐ Handy Guide to Motor Selection 51B6052

☐ Squirrel Cage Motors 51B6210

Control

☐ Handy Guide to Starters 14B7733

☐ Reduced-voltage Starters 14B7215

***Texrope* Drives**

☐ Handy Guide to *Texrope* Drives 20B6051

☐ *Vari-Pitch* Drive Engineering Data 20B7499

Name.................................... Title.................... Company....................

Address.................................... City and State....................

CUT OUT HERE

DESIGNING WITH ALUMINUM

This is one of a series of information sheets which discuss the properties of aluminum and its alloys with relation to design. Extra or missing copies of the series will be supplied on request. Address: Advertising Department, Kaiser Aluminum & Chemical Sales, Inc., 1924 Broadway, Oakland 12, California.

NO. 2

THERMAL CONDUCTIVITY, REFLECTIVITY

CONSIDER USE OF ALUMINUM ALLOYS WHERE HEAT CONDUCTION OR RADIANT HEAT REFLECTION IS REQUIRED

AT first glance it may appear to be a paradox that aluminum is both a good thermal conductor and a good reflector of radiant heat, but two separate phenomena and properties are involved.

Conduction is the process of heat transfer through a material by kinetic energy. Radiation is the transmission of energy from a source to a receiver through space by electromagnetic waves; those chiefly responsible for heat radiation are similar to but of no longer wave length than those for light. When absorbed, the radiant energy increases the temperature of the absorbing body.

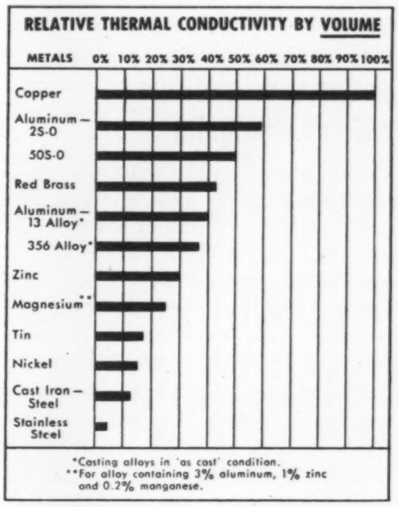
The possession of these two distinct properties—thermal conduction and radiant reflectivity—has proved of outstanding value in many successful applications of aluminum, especially as they are combined with such other properties of aluminum as corrosion resistance, light weight and strength, workability and economy.

Aluminum best conductor on weight basis

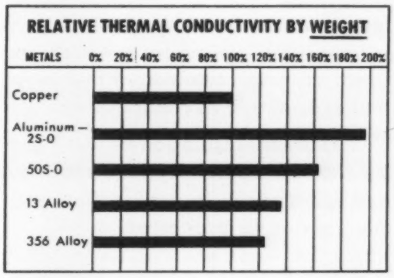
Of the commercial metals aluminum ranks second only to copper in thermal conductivity on a volume basis. On a *weight* basis, however, aluminum has the highest thermal conductivity, with various aluminum alloys being superior to copper by a wide margin.

The relationship between some aluminum alloys and other metals with respect to thermal conductivity, as illustrated in the charts in the next column, shows why aluminum is worth considering where it is necessary to conduct or dissipate heat.

Localized "hot spots" resulting from use of a metal of inferior conductivity are troublesome and reduce efficiency, whether they occur in a cooking utensil or in a more complex application.


RELATIVE THERMAL CONDUCTIVITY BY VOLUME

*Casting alloys in 'as cast' condition.
**For alloy containing 3% aluminum, 1% zinc and 0.2% manganese.


RELATIVE THERMAL CONDUCTIVITY BY WEIGHT

How aluminum's high thermal conductivity can greatly improve efficiency is demonstrated by its use in internal combustion engines, where one of the major problems is high temperature in the engine envelope. By dissipating heat rapidly, aluminum cylinder heads reduce temperature in the combustion chamber by as much as 100° F., thereby making it possible to obtain higher compression ratios by preventing detonation caused by a "hot spot." It has been found also that aluminum cylinder liners surfaced with hard plating have given a very considerable power increase over cast iron liners because of better heat dissipation.

More and more, the trend is toward greater utilization of aluminum to produce higher performance engines. In fact, power plants made almost entirely of aluminum are built not only for aircraft but also for marine application, tanks, trucks and such popular, work-saving products as power lawn mowers and portable chain saws. The light weight, corrosion resistance and workability of aluminum are beneficial as well in their design, manufacture and operation.

The thermal conductivity properties of aluminum also play a part in its use in torque converters (discussed in No. 1 of this information series, dealing with "Light Weight with Strength") by eliminating the need to make special provision for cooling to handle heat generated during operation.

An interesting specialized use of aluminum's conductivity, made practical because aluminum can be economically rolled to thin foil, is seen in cigarette-proof tables, desks and counter tops. A layer of foil just beneath the surface dissipates heat from the burning tip of a carelessly laid cigarette so rapidly that there is no scorching or burning.

Aluminum reflects short, long waves

Aluminum is highly reflective to both short wave (solar) and long wave radiant energy. Possession of this quality means also that aluminum is characterized by low absorption of solar heat and low emissivity, or radiation, of long waves.

PLEASE TURN TO NEXT PAGE ➡

CUT OUT HERE

DESIGNING WITH ALUMINUM Continued

In per cent, reflectivity plus absorption, or reflectivity plus emissivity, equals 100. Although polished aluminum surfaces such as bright aluminum foil have the highest reflectivity, up to 95% or 97%, even aged mill finish aluminum sheet retains this property to a marked degree.

The table below gives approximate values of these properties for aluminum in comparison to some other surfaces:

EMISSIVITY, ABSORPTION OF VARIOUS MATERIALS

	Long Wave Emissivity in %* (Radiation)				Solar Absorption in %* (Short Wave)	
	50-150°F		1000°F			
	New	Aged	New	Aged	New	Aged
Bright Aluminum Foil	3	5	5	10	5	15
Bright Aluminum Roofing Sheet	5	20	10	20	20	40
Mill Finish Aluminum Sheet	8	20	11	20	25	40
White Paint (Flat)	85	95	60	75	12	50
Colored Paint	85	95	..	..	65	88
Galvanized Iron	10	60	..	..	30	90
Black Non-Metallic Surfaces	87	98	..	..	85	98
Window Glass	90	95	..	..	Transparent**	
Wood	90	98	..	..	98	..
Steel Sheet	65	90	80	97	..	..

*Per cent reflectivity is 100% minus value listed.

**Actually reflects about 8% of sun's rays.

Reflectivity useful in varied ways

Inasmuch as radiant heat is frequently the major source of the total heat load, examination of these values shows why designers in various fields are making more use of aluminum to solve different problems.

It is obvious also how an aluminum roof makes a building cooler in summer—it reflects a high percentage of the solar heat, and only a small percentage of what is absorbed is reradiated by long-wave emissivity to the interior—and why aluminum foil makes excellent reflective insulation, whether new and bright or old and dusty.

Other ways in which the heat reflective property is being used with substantial benefit include reflective shields behind radiant heaters, radiant heat baffles in residential furnaces and radiant heat shields to protect workers who must tend high-temperature industrial furnaces.

Because of its low emissivity, a heating duct made of bare aluminum delivers more heat than other standard types of duct construction. Comprehensive tests (report available on request) between 12-inch diameter round ducts approximately 100 feet long showed that a duct made of new aluminum gave a temperature drop of only 43° F., as compared with a 61° drop for an asbestos paper covered galvanized duct.

It is possible, if so desired, to achieve directional radiation by painting or otherwise coating one side of aluminum and leaving the other side bare. When the metal is heated, the painted side will radiate heat but the bare side will emit little heat.

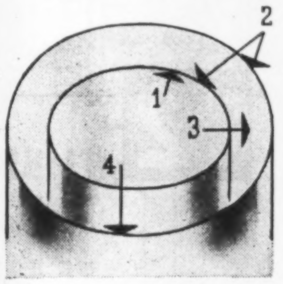
Better vent and flue pipe of aluminum

Use of aluminum in a double-wall construction, essentially an inner and outer pipe of aluminum sheet separated by a ventilated air space, has resulted in a highly efficient gas vent and flue pipe that fully meets Underwriters' Laboratories, Inc., Type B requirements without restriction.

The properties of aluminum as well as its design contribute to the value of this pipe. The inner pipe, being of small thermal mass (and of high conductivity, though that is of less importance), rises quickly to temperature when the gas appliance is turned on; it provides quick, strong draft, thorough removal of flue gases and elimination of condensation.

Maximum insulation is provided by the low emissivity of both inner and outer pipes in conjunction with the insulative properties of the air space between them. The result is that this type of pipe keeps adjacent wood surfaces from exceeding 90° F. above room temperature, the UL limit, even when flue gas temperature is at the American Gas Association-permitted maximum of 550° F. In other words, aluminum makes possible *a safer as well as a better operating construction* than other commonly used materials. Other advantages from the use of aluminum are light weight with easier installation, durability through freedom from cracking or breaking, resistance to corrosive influences, and economy.

HOW ALUMINUM VENT PIPE WORKS



1. Inner pipe heats rapidly.
2. Low emissivity of outside surfaces of both pipes provides minimum radiation.
3. Ventilated air space provides high insulation.
4. Inside surface of outer pipe reflects radiant heat.

Where heat flow occurs, investigate aluminum

If heat transmission or reflection is involved in a design and application problem, it will pay to investigate the use of aluminum alloys. Along with high conductivity or reflectivity, other aluminum properties will provide additional benefits.

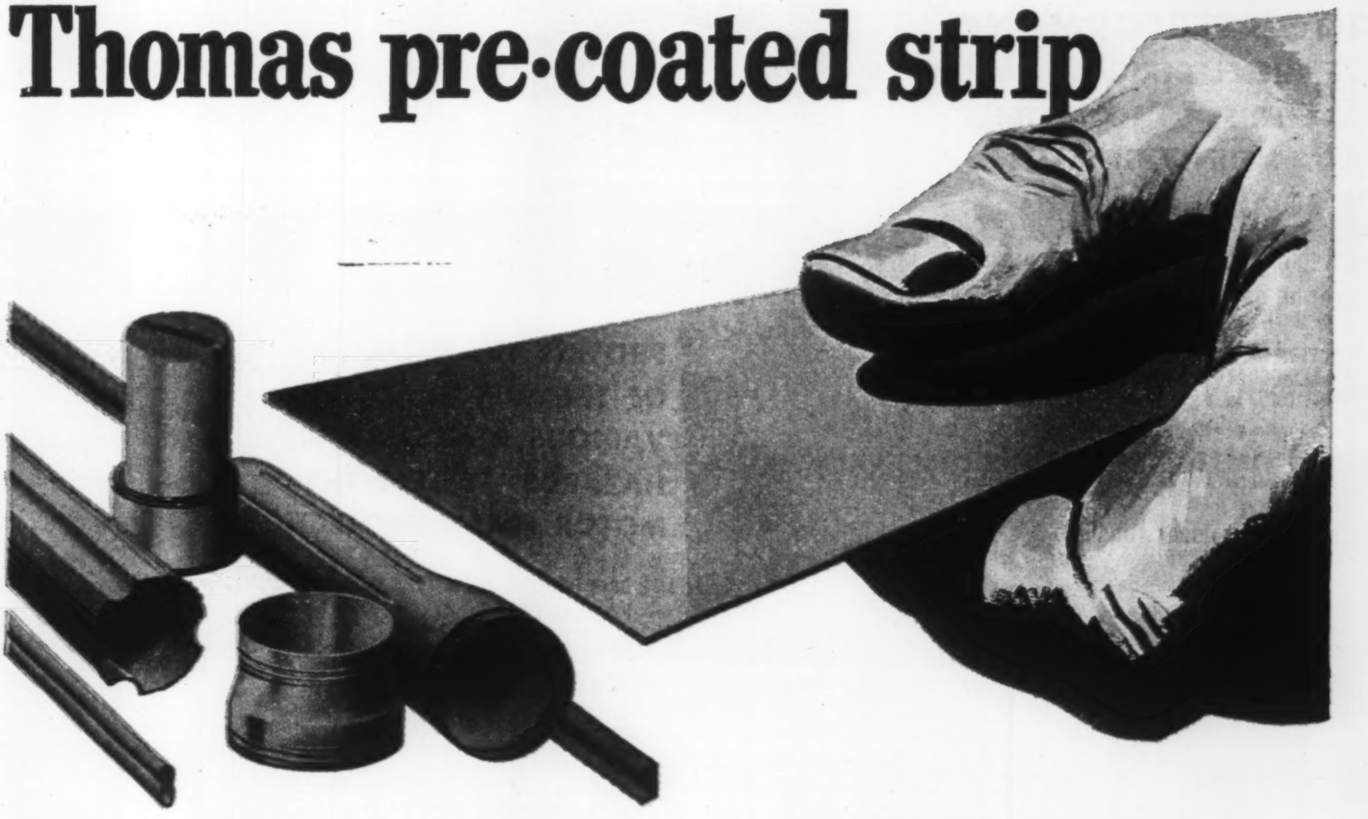
Kaiser Aluminum engineers experienced in product design, development and fabrication will gladly assist you in getting the most from aluminum's unique combination of properties. Call or write any Kaiser Aluminum office, in principal cities. Kaiser Aluminum & Chemical Sales, Inc., Oakland 12, Calif.

Kaiser Aluminum

see our catalog in
PRODUCT DESIGN FILE
or write for copy

Setting the pace . . . in growth, quality and service

Here's a production idea that cuts costs...improves products... Thomas pre·coated strip



Thomas Cold Rolled Pre-coated Strip steel is more than a quality product—it's a production idea that helps reduce costs—speeds operations and makes a better finished product.

Take Thomas electro-plated copper strip for example. It serves as a die lubricant and stretches die life, protects parts in process against rust, is used as a low-cost final finish for many products and increases efficiency of tinning, soldering and brazing operations. In many instances entire operations such as raw material preparation, intermediate cleaning, buffing and final plating all may be eliminated.

Profits and production start quicker, get there faster when you include Thomas Pre-coated Strip steel in your plans to produce better products. To learn how you can enjoy these advantages write today for information.

Cold-rolled strip steel electrolytically pre-coated with Zinc, Copper, Brass, Nickel and Lead-Alloy in Natural, Planished and Buffed Finishes—Hot Dip Tin and Lead-Alloy Coated—Lacquer Coated in Colors—Annealed Spring Steel—Alloy Strip Steel—Uncoated Strip Steel. Carefully produced to your specifications.

Thomas Strip

a product of

Pittsburgh Steel Company

Thomas Strip Division • Warren, Ohio

STEP 1

ENGINEER THE PERFORMANCE OF YOUR
a Century application engineer will
from this wide range of

FOR TOP PERFORMANCE SELECT THE ELECTRICAL CHARACTERISTICS TO MATCH THE LOAD FUNCTIONS OF YOUR EQUIPMENT

- ☐ SINGLE PHASE OR POLYPHASE A.C. OR D.C.
- ☐ SELECTION OF RATING FROM WIDE RANGE —1/8 to 400 H.P.
- ☐ SELECTION OF PROPER LOADING FACTOR FOR SAFE TEMPERATURES AND EFFICIENT OPERATION:
  - ☐ Continuous general purpose rating.
  - ☐ Short time special rating.
  - ☐ With consideration to ambient temperatures for either of these.

SELECTION OF VARIOUS TORQUE CHARACTERISTICS FOR:

- ☐ Starting torque required which varies with class of equipment.
- ☐ Accelerating torque required which varies with inertia—friction—compression of the load.
- ☐ Maximum torque required which may vary with momentary overloads.

SELECTION OF TORQUE CHARACTERISTICS AND RATING FOR REVERSING ROTATION OF LOAD:

- ☐ Where motor comes to full stop before reversing.
- ☐ For instantaneous reversing (plugging) with reference to load inertia or other load factors.

SELECTION OF RATING FOR "START" AND "STOP" CYCLE FOR:

- ☐ Standard ratings for infrequent starts and stops.
- ☐ Special rating depending on frequency of starts and stops.

SPEED REGULATION AND CONTROL FOR:

- ☐ Select normal slip for good constant speed regulation.
- ☐ Select high slip, to absorb shock of impact loads.
- ☐ Select adjustable varying speed for uniformly constant load.
- ☐ For speed adjustment in fine steps, variable load, use adjustable voltage control.
- ☐ For speed adjustment in wide fixed steps, use multi-speed motors furnished for:
  - ☐ Constant H.P.
  - ☐ Constant torque
  - ☐ Variable torque

SELECT MOTOR WITH:

- ☐ Normal starting current for power circuits with good voltage regulation.
- ☐ Lowest starting current for power circuits where voltage fluctuates widely (R.E.A. lines).

STEP 2

PROTECT THE VITAL PARTS OF THE MOTOR FROM VARIOUS ATMOSPHERIC HAZARDS — SELECT THE MOTOR FRAME PROTECTION

☐ **DRIP PROOF — OPEN TYPE GENERAL PURPOSE FRAME**

For normal atmospheric conditions.

☐ **SPLASH PROOF — OPEN TYPE FRAMES**

Can be used out of doors without further protection or in plants where equipment must be washed down with a hose. For plants like dairies or other processing plants. Or for cooling towers, oil field pumping units, etc., out of doors.

☐ **DUST PROOF — TOTALLY ENCLOSED FAN COOLED FRAME**

The vital parts of the motor are sealed in. Used where the atmosphere is charged with abnormal amounts of dust, grit, oil fog, etc. This frame has high acceptance in high speed mass production metalworking plants or wherever a highly charged atmosphere would affect the life of the motor.

☐ **EXPLOSION PROOF — TOTALLY ENCLOSED FAN COOLED FRAME**

The frame is sealed in, in a manner which prevents a spark inside the frame from igniting combustible materials or gases outside the frame. The motors have an "Underwriters' Label" indicating the design has been approved by the Underwriters' Laboratories for certain specified classes of explosives.

☐ **TEXTILE — OPEN TYPE FRAME**

This motor is designed with wide open air passages, with smooth surfaces. It actually sheds lint, with which the air is highly charged in textile plants.

CALL A Century APPLICATION ENGINEER ...from a Century Branch Office, located in principal cities in U. S.

CENTURY ELECTRIC

PRODUCTS THROUGH SKILLFUL MOTOR APPLICATION

help you select the right motor—
Century motor specifications

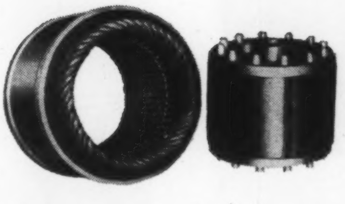
For more than 50 years,
Century motors have been satisfying the requirements of equipment manufacturers — often with the most exacting specifications. This has produced a great teamwork between Century engineers and the customers' engineering department.

"Century OFFERS hundreds of mechanical forms for best adaptation to your equipment.
ASK FOR IT—
WE HAVE IT!"

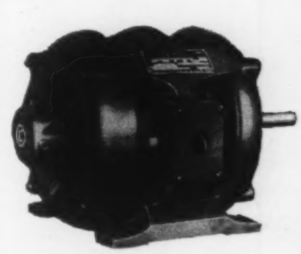
STEP 3

FOR IDEAL ADAPTATION OF THE MOTOR TO YOUR EQUIPMENT—

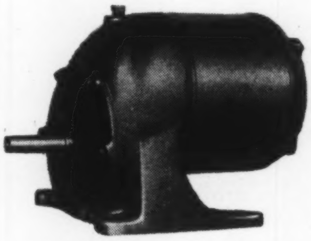
Here are a few samples of the many mechanical forms to select from


☐ Hermatically sealed refrigeration motor

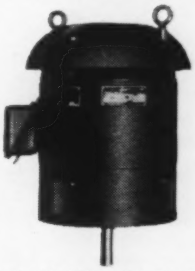
☐ Oil burner motor


☐ Textile motor

☐ Vertical fan motor

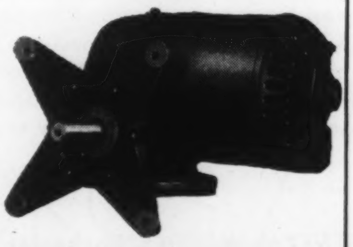

☐ Parallel shaft gear motor

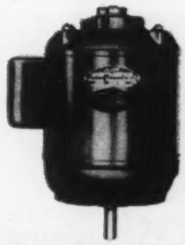
☐ 20 kw generator


☐ Vertical ball-bearing flange mounted motor

☐ Vertical motor with brak attachme

Ask about a sample
Century motor, scientifically selected, for actual test performance on your equipment.
Ask about Century's National Network of Authorized Motor Service Stations to solve your motor service problems in the field.


☐ Pedestal mounted gear motor


☐ Fractional capacitor motor

☐ Totally enclosed DC marine motor

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GM tubing

MEETS THE MOST EXACTING DEMANDS OF Westinghouse COROX® HEATERS

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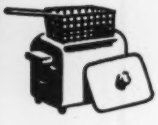
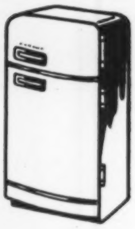
HAND IRONS

VAPORIZERS


DEEP-FAT FRYERS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LOW COST

WIDE RANGE OF SIZES AND FINISHES

GM Steel Tubing is available in welded single wall or copper brazed double wall construction, in sizes from ⅛″ to ⅝″ O.D., and in straight lengths or in 120′ to 1000′ continuous coils. Choice of plain, Terne coated, copper plated, or Fuse-Kote (copper fused) finish.

WELDED SINGLE WALL

COPPER BRAZED DOUBLE WALL

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Our illustrated brochure tells why GM Tubing is first in the field for lasting quality, adaptability and low cost. Send today for your free copy.

THE FAMOUS WESTINGHOUSE Corox tubular heating unit demands a metal tube that can be readily formed into the most intricate shapes for cast-in, immersion or clamp-on applications. Rugged, adaptable GM Steel Tubing meets this demand—plus the extra requirements of close I.D. tolerance and minimum weld seam.

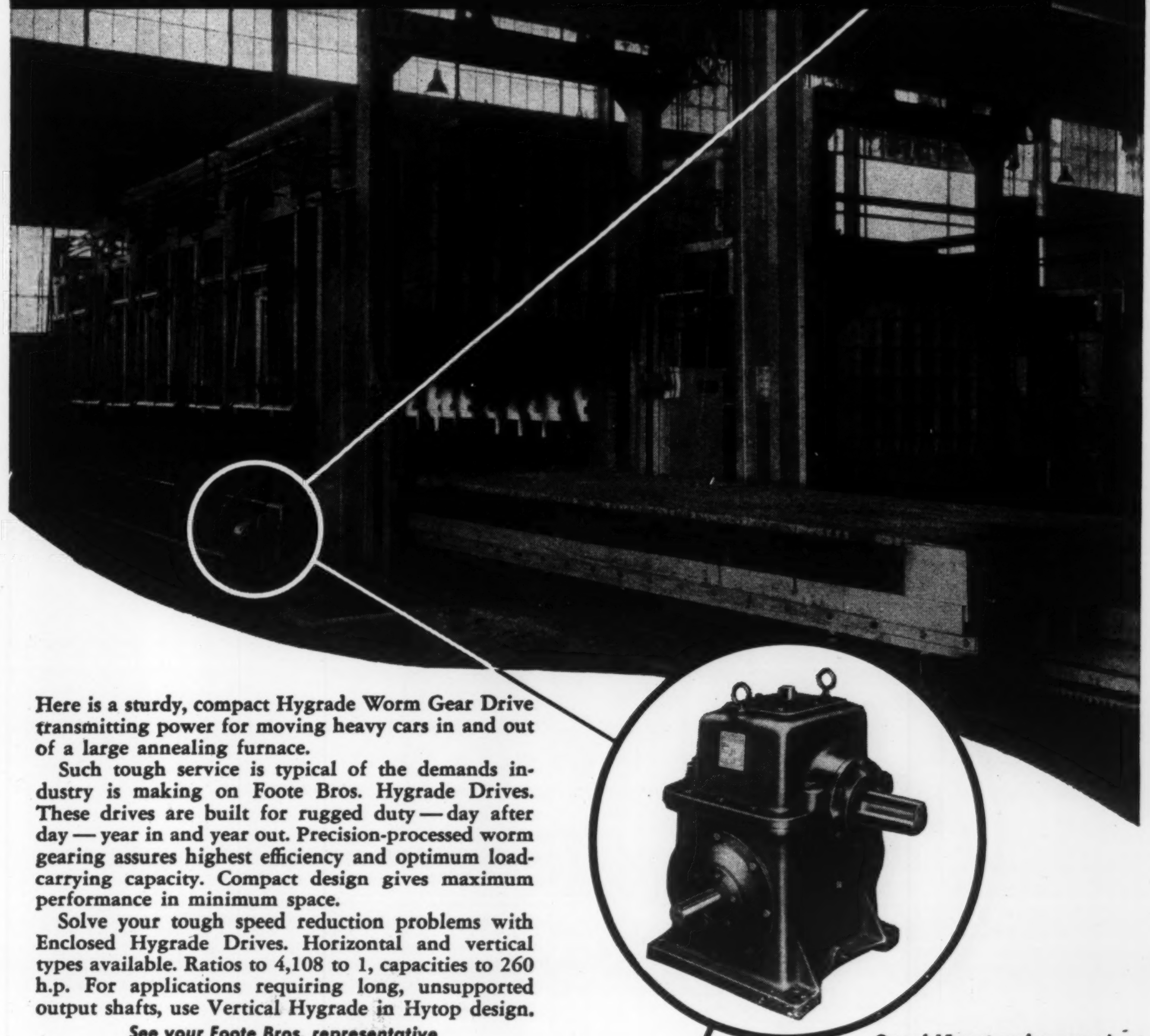
In hundreds of other products, this low-cost steel tubing is serving as part of the mechanical structure or for the passage of liquids or gases. It lends itself to all types of fabricating operations . . . for which Rochester Products offers complete fabricating facilities, if desired.

Every day, Rochester Products turns out *hundreds of miles* of GM Steel Tubing in one of America's best equipped plants—with the skill and "know-how" gained through nearly 20 years of GM research and development. It will pay you to consider its time-and-money saving features!

ROCHESTER PRODUCTS, ***DIVISION OF GENERAL MOTORS,*** **Rochester, N. Y., U. S. A.** **GM STEEL TUBING**

FOR RUGGED DESIGN TROUBLE-FREE OPERATION...

Choose HYGRADE DRIVES!



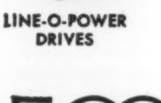
Here is a sturdy, compact Hygrade Worm Gear Drive transmitting power for moving heavy cars in and out of a large annealing furnace.

Such tough service is typical of the demands industry is making on Foote Bros. Hygrade Drives. These drives are built for rugged duty—day after day—year in and year out. Precision-processed worm gearing assures highest efficiency and optimum load-carrying capacity. Compact design gives maximum performance in minimum space.

Solve your tough speed reduction problems with Enclosed Hygrade Drives. Horizontal and vertical types available. Ratios to 4,108 to 1, capacities to 260 h.p. For applications requiring long, unsupported output shafts, use Vertical Hygrade in Hytop design.

See your Foote Bros. representative or write for information

One of 15 car-type furnaces using Hygrade Drives at Warren, Ohio, plant of Copperweld Steel Company. Installed by Pennsylvania Industrial Engineers Division, Amsler Morton Co.



LINE-O-POWER DRIVES

MAXI-POWER DRIVES

FOOTE BROS.-LOUIS ALLIS GEARMOTORS

FOOTE BROS.

Better Power Transmission Through Better Gears

FOOTE BROS.
GEAR AND MACHINE CORPORATION
Dept. O, 4545 South Western Boulevard
Chicago 9, Illinois

Please send me a free copy of Bulletin HGB on Foote Bros. Hygrade Worm Gear Drives.

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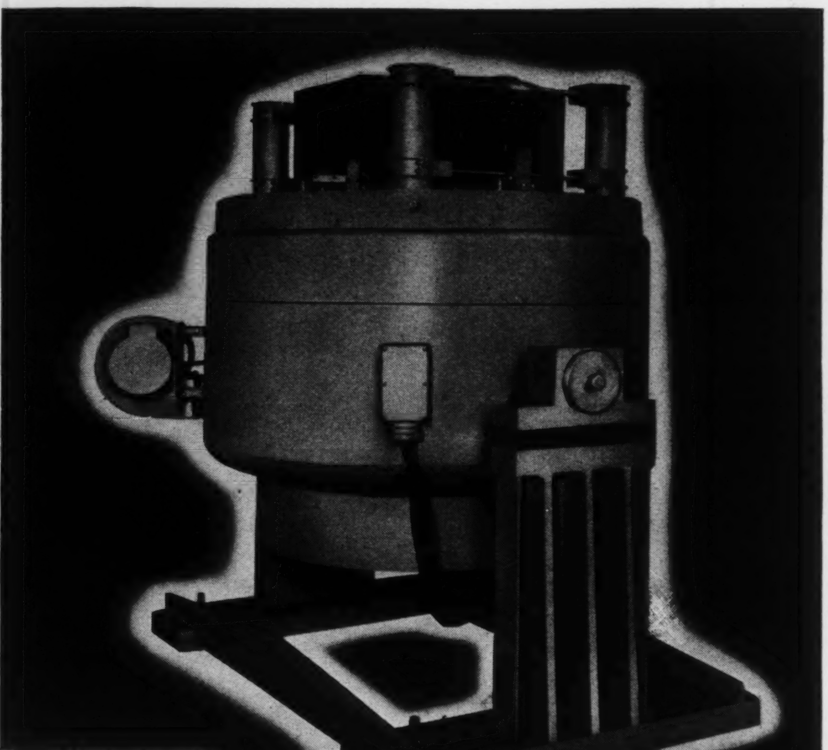
City...................................Zone...........State....................

Largest Vibration Exciter Ever Built

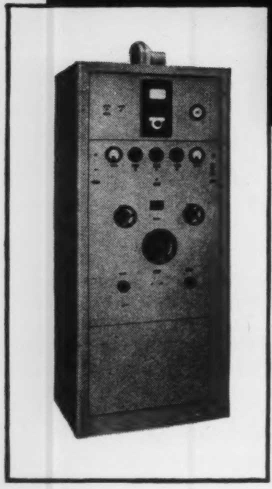
- ***New MB shaker delivers 10,000 pounds force output!***
- ***Widens scope of vibration testing to MIL-E-5272 and other specifications!***



HERE's the latest—and the *largest* — vibration exciter ever built for shake testing. Developed by MB vibration specialists, this unit incorporates all the advances made in the last seven years for assuring dependable operation, pure table motion, and absence of resonances. These include specially designed table flexures, forced air cooling, built in protection against overtravel of the table and against misoperation of the equipment.

This extra heavy duty, conservatively rated, electromagnetic shaker has the capacity and endurance to permit continuous testing at rated output. It will handle anything from electrical components to air-frame structures.

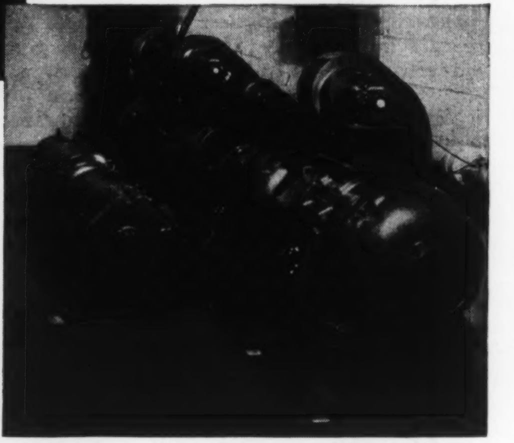
Remember—available MB Vibration Exciters now range from 5 pounds output size all the way up to this new giant. Make MB your headquarters for help on vibration testing and other problems.



MODEL C-100 VIBRATION EXCITER has ½" total table travel. Flexure design supports heavy table loads without sacrificing stroke. Trunnion support permits operation in all positions from horizontal to vertical, and has built-in vibration isolation. Operating range: 5 to 500 cps.

◀ **CONTROL PANEL** (Model T-100) assures proper operation of equipment with interlocked controls. Accurate, easy, continuous control of force and frequency permits quick adjustments, or "scanning" over entire operating range. MB Vibration Meter provided; also running time meter.

ROTATING POWER SUPPLY rated to deliver full power without need for power factor correction. Blowers cool each unit separately. Alternators feed driver coil of shaker, with minimum harmonic distortion. ▶

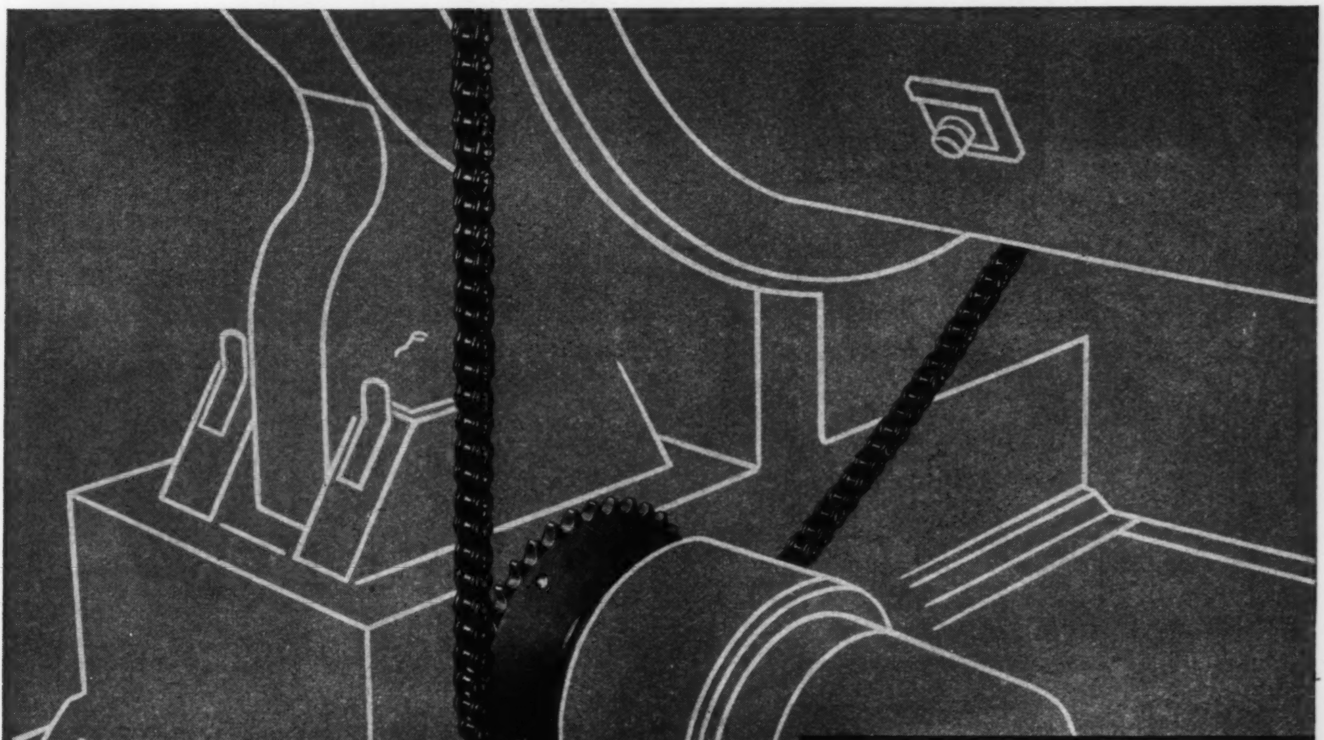


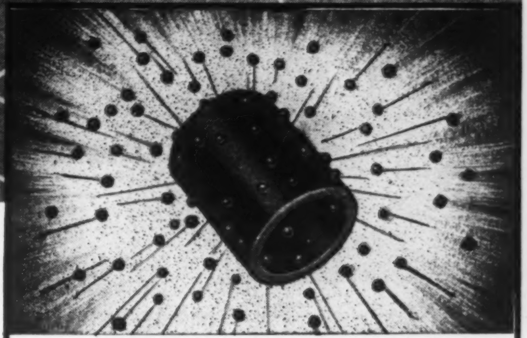
THE MB MANUFACTURING COMPANY, INC.
1060 STATE STREET, NEW HAVEN 11, CONN.

BULLETIN TELLS MORE
Contains specifications, operating information and helpful hints on usages of the complete line of MB Exciters. Write for Bulletin I-VE-3.

PRODUCTS AND EQUIPMENT TO CONTROL VIBRATION • TO MEASURE IT • TO GENERATE IT

There's EXTRA LIFE built into LINK-BELT roller chain





Look for the distinguishing darkened rollers. Thousands of tiny steel balls hammer the metal—"cold work" each roller . . . pay off in extra fatigue life . . . added ability to withstand shock and impact of today's heavier loads.

Shot-peened rollers are just one of many engineering extras you get from LINK-BELT

WHETHER it's for drive or conveyor service, every Link-Belt Roller Chain gives you a performance bonus. In addition to shot-peened rollers, lock-type bushings multiply capacity to withstand shock loading. And closer heat-treat control, rigid testing and thorough inspection pay off in greater uniformity . . . extra years of life. Link-Belt Precision Steel Roller Chain is built in single or multiple widths, 3/8″ through 3″ pitch. Double pitch 1″ through 3″. A call to your nearby Link-Belt office will bring you prompt, expert service. Send for Engineering Data Book No. 2457.

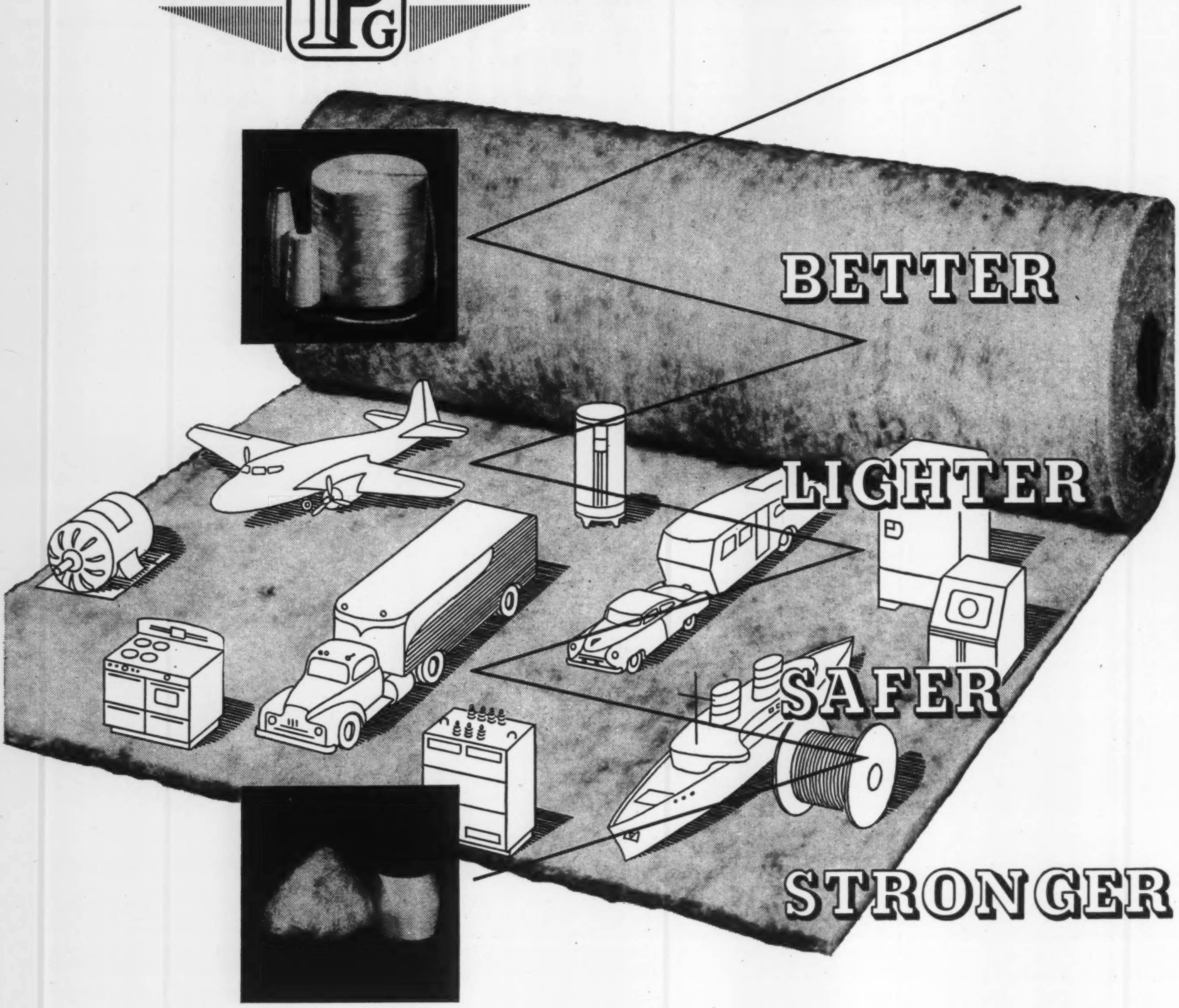
13,119-A

LINK-BELT

ROLLER CHAIN & SPROCKETS

LINK-BELT COMPANY: Plants: Chicago, Indianapolis, Philadelphia, Colmar, Pa., Atlanta, Houston, Minneapolis, San Francisco, Los Angeles, Seattle, Toronto, Springs (South Africa), Sydney (Australia). Sales Offices, Factory Branch Stores and Distributors in Principal Cities.

FIBER GLASS HELPS MAKE PRODUCTS



Perhaps your product needs lightweight, space-saving thermal and acoustical insulation. Or you may be interested in the strongest of all plastic reinforcements, or electrical insulations that prolong the life of apparatus, or a fiber for producing flame-proof textiles that may be as sheer or as rugged as your use requires. Pittsburgh Fiber Glass can meet any of these needs—and many more—with performance that makes products better, safer, lighter, stronger.

We'll be glad to give you complete product data and information on facilities for serving you. Technical assistance is also available. Pittsburgh Plate Glass Company, Fiber Glass Division, 420 Duquesne Way, Pittsburgh 22, Pa. District Sales Offices: Chicago, Cincinnati, Cleveland, Detroit, New York, Washington.

SUPERFINE INSULATION—"AA" and "B" fibers in a complete range of blanket roll sizes, thicknesses, densities, facings.

YARNS, ROVING and STRANDS—Made with the continuous filament process to an exceptional degree of fiber uniformity.

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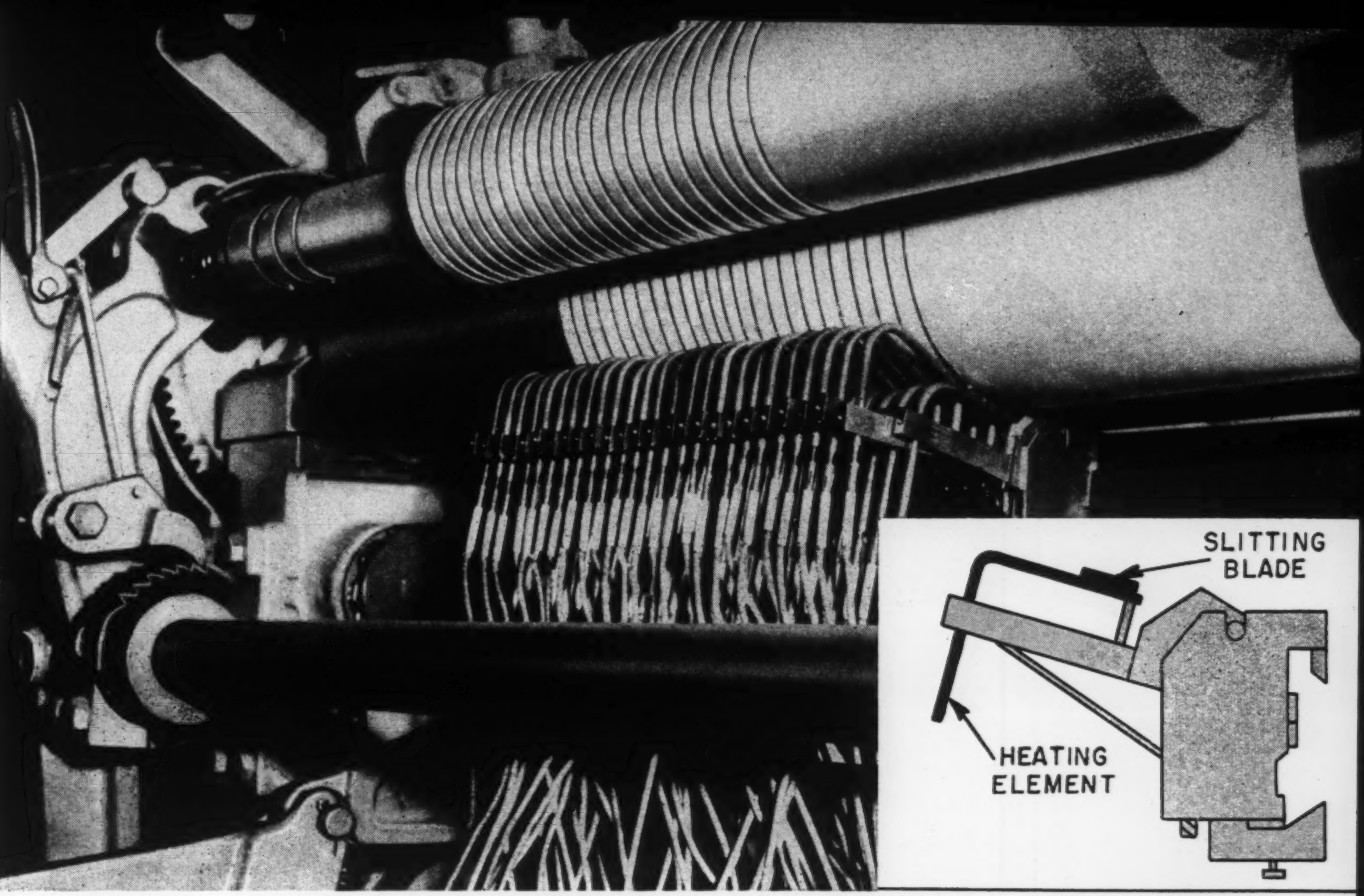
PAINTS · GLASS · CHEMICALS · BRUSHES · PLASTICS

PITTSBURGH PLATE GLASS COMPANY



BLADES HEAT AND COOL QUICKLY. PREVIOUSLY, RESIDUAL HEAT IN CUTTING WHEELS MADE NECESSARY LONG COOLING PERIODS.

Completely new machine made possible by Calrod* heaters

Electric heat improves working conditions, increases efficiency of Cameron's Sealcut®

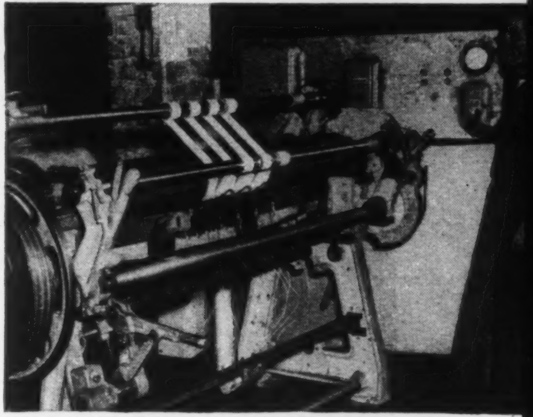
Calrod tubular heaters have increased the operating efficiency of new Sealcut fabric-slitting machines according to the manufacturer, Cameron Machine Company of Brooklyn, New York.

"With other heat sources, the minimum width we could achieve was one inch," says Cameron. "Electrically heated straight blades cut acetate rayon and nylon strips to any width from ¼″ up, across the full width of the fabric." These blades melt razor-thin slits as the fabric passes between them and the rewinder platen roll, and heat-seal the edges immediately to prevent fraying.

"We have standardized on electric heat supplied by Calrod tubular heaters," Cameron's engineers report. "Now we can assure our customers of clean, cool working conditions and more compact equipment. Our first electrically heated Sealcut units have been in operation over a year now, and are giving excellent service."

YOU, TOO, CAN PROFIT by incorporating electric heat into existing designs, or building it into new machinery and equipment. The reputation of Calrod heaters is known and respected by your customers. You can get prompt shipment on any size, rating, shape or sheath material. Consult your G-E Heating Specialist *early* in your planning. For more information on applying electric heat to the machines you build, mail the coupon at right.

Reg. Trade-mark of General Electric Company.



OPERATOR SETS ACCESSIBLE CONTROLS on the Sealcut. The sealed edges of strips are resistant to fraying and raveling in use.

Section 720-97
General Electric Co.
Schenectady 5, N. Y.

Please send me ☐ for immediate project, ☐ for reference, free bulletin GEA-5866, "Built-in Electric Heat for OEM's."

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GENERAL ELECTRIC

handle more shapes—sizes and materials on one machine!

—give the machines you build extra "Change-over Capacity"—extra *profit* capacity with—

REEVES

VARIABLE-SPEED DRIVES

With so many plants now converting to defense production, your customers are in critical need of machines that can handle the greatest possible variety of work without costly delays in changing over from one job to another.

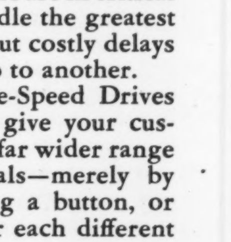
By making REEVES Variable-Speed Drives standard equipment, you can give your customers machines that handle a far wider range of shapes, sizes, and materials—merely by turning a handwheel, touching a button, or automatically. And, *always,* for each different shape, size or material, the REEVES Drive will deliver *exactly* the right speed to assure the maximum rate of production.

Take the first step today in this vital improvement of your product. Write for the name of the REEVES Speed Control Engineer in your locality. He'll give you full details on *America's only complete line of variable speed drives . . .* the reliable REEVES line . . . competent counsel on how to adapt REEVES to your particular needs. No obligation, of course.

REEVES PULLEY COMPANY · COLUMBUS, INDIANA

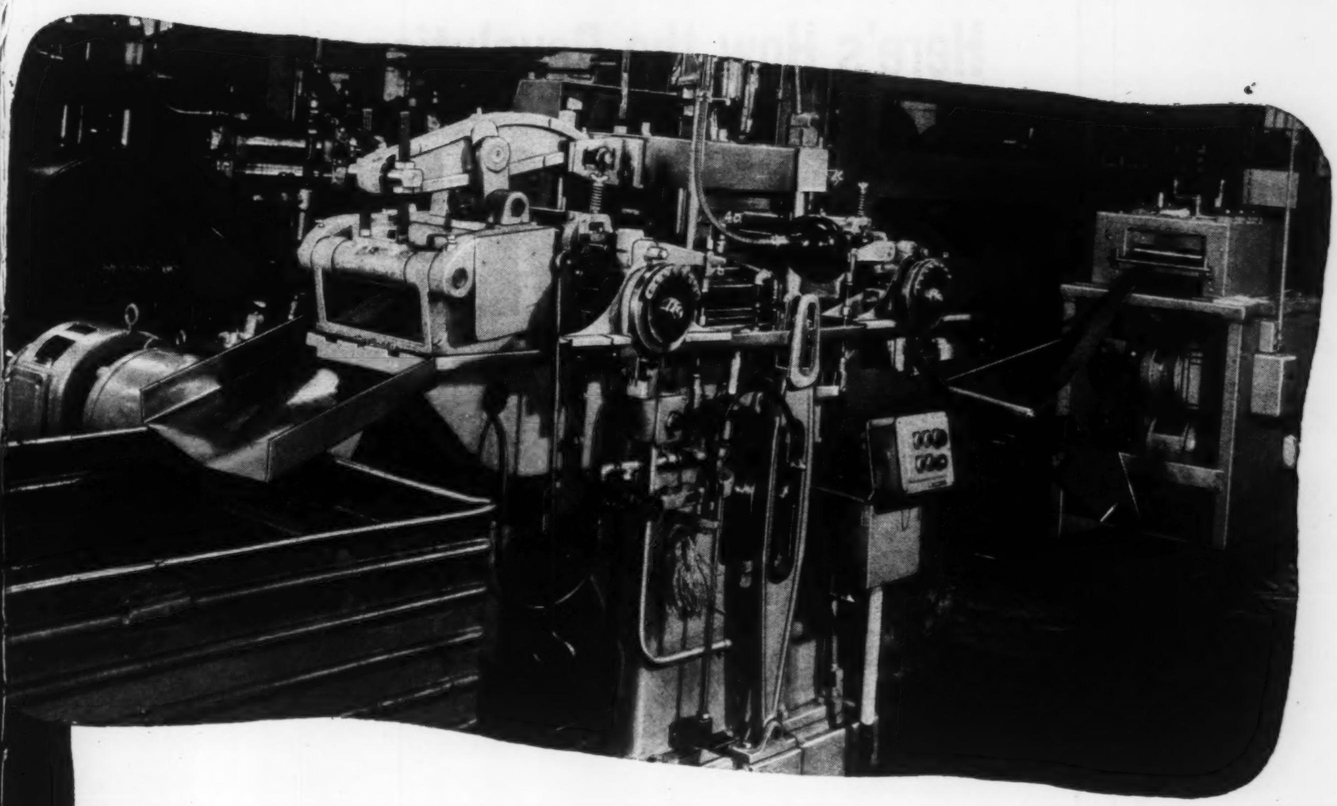
Recognized leader in the specialized field of variable speed control

Ask for complete information, including engineering drawings and technical data, on the full line of REEVES Variable-Speed Drives and Controls. Send for Catalog No. H75b-3N.



accurate · variable

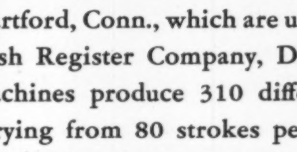
REEVES *Speed Control*



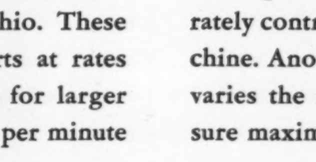
Example: Here's how National Cash Register uses REEVES-equipped machines to handle more shapes, sizes and materials

REEVES Variable-Speed Drives are standard equipment on the three sizes of Henry & Wright Dieing Machines, manufactured by Henry & Wright, Hartford, Conn., which are used by The National Cash Register Company, Dayton, Ohio. These machines produce 310 different parts at rates varying from 80 strokes per minute for larger parts or heavier stock to 400 strokes per minute for smaller parts or lighter stock. Machine speeds must be changed over that wide range with the least possible delay. In above installation, a REEVES Vari-Speed Motodrive (arrow at right) accurately controls the rate of feed into the dieing machine. Another REEVES Motodrive (arrow at left) varies the machine's strokes per minute, to assure maximum production of each different part.

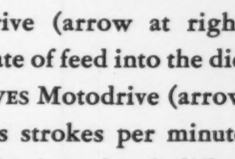
Make REEVES standard equipment on your machines . . . choose from the complete line built around these three REEVES basic units



VARIABLE SPEED TRANSMISSION provides infinite, accurate, stepless speed adjustability over a wide range—as high as 16 to 1. Sizes to 87 hp.



VARI-SPEED MOTOR PULLEY converts any standard, constant-speed motor to a variable speed drive. Speed variations to 4 to 1. Sizes to 10 hp.



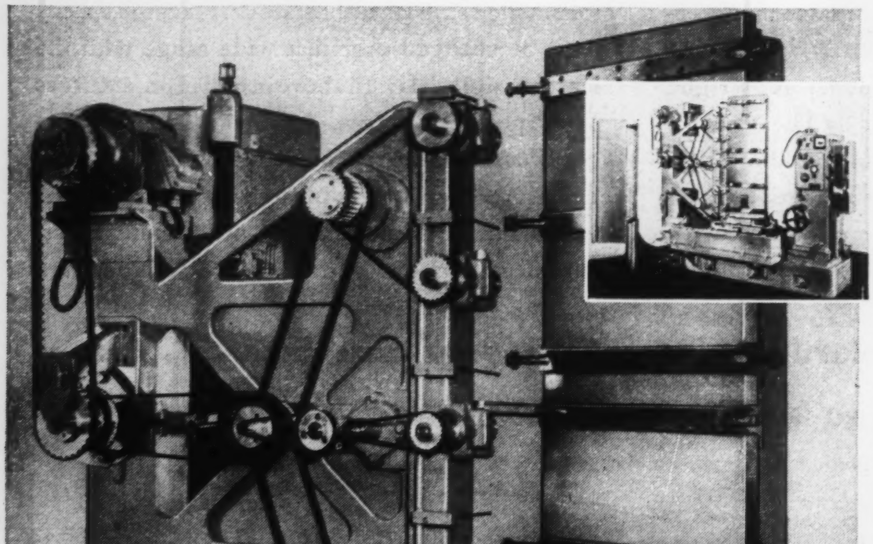
VARI-SPEED MOTODRIVE® combines motor, speed-changing mechanism and gear reducer in one unit. Speed variations as great as 10 to 1. Sizes to 25 hp.

Here's How the Revolutionary

Gilmer "TIMING"®

...made possible improved tool life and finishes on the

PRATT & WHITNEY AUTOMATIC DUPLICATING MACHINE

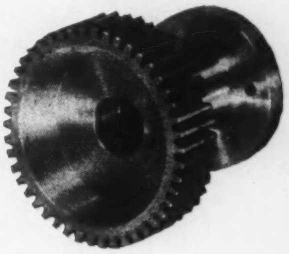


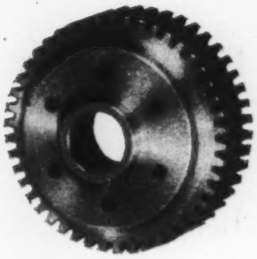
On this machine, the two upper and two lower cutter spindles, driven by Gilmer "Timing" Belt Drives, simultaneously produce four identical forging dies (such as for jet turbine blades) under control of the center *tracer spindle* which follows a hard master shape. The machine duplicates to very close tolerances, using either high-speed steel or carbide cutting tools.

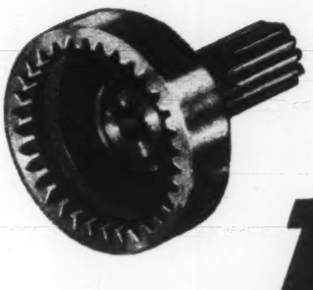
Since the life of carbide tools is greatly reduced, and finish impaired, by any slippage or slowing down of the spindle drive, the round belts formerly employed not only required much larger-diameter pulleys but also produced unsatisfactory tool life, as some slippage was bound to occur. To hold this to a minimum, belts had to be installed under high initial tension, which also resulted in frequent belt breakage.

The answer to the problem proved to be a *positive* slip-proof drive requiring no initial tension, no lubrication, no large pulleys — the Gilmer "Timing" Belt Drive! Now, a total of eight "Timing" Belt Drives transmits perfectly synchronized power from the motor to the five spindles. Belt slippage and tool chatter is positively eliminated, assuring maximum life from carbide tools and uniformly high quality finishes on the work. Belt breakage is a thing of the past. Belt pulleys are considerably smaller, yet provide a speed range of 900 to 10,000 rpm required for the interchangeable use of high-speed steel and carbide cutting tools.

NEW CONCEPTS IN FINE-PITCH GEAR SUPPLY!







RYNEL

PRECISION GEARS

Laboratory Tested for Precision Requirements

Rynel's modern gear checking laboratory delivers fine-pitch gears to your assembly line — as specified. From blanks to stated gear tooth performance, each Rynel fine-pitch gear must meet rigid quality standards set by Rynel gear engineers. Precision checked at each operation, a final Gear Lab check-out furnishes you with a test run of operating quality and interchangeability . . . exactly to your specifications.

Call a Rynel Engineer for service on your fine pitch gear supply problems. He can visit you the same day you call through Rynel's exclusive Air Lift Service.

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301 Miller Street, Sterling, Illinois • **4730 N. Western Avenue, Chicago, Illinois**

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DESIGNERS AND SUPPLIERS

Electronic
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and
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FINE-PITCH GEARS

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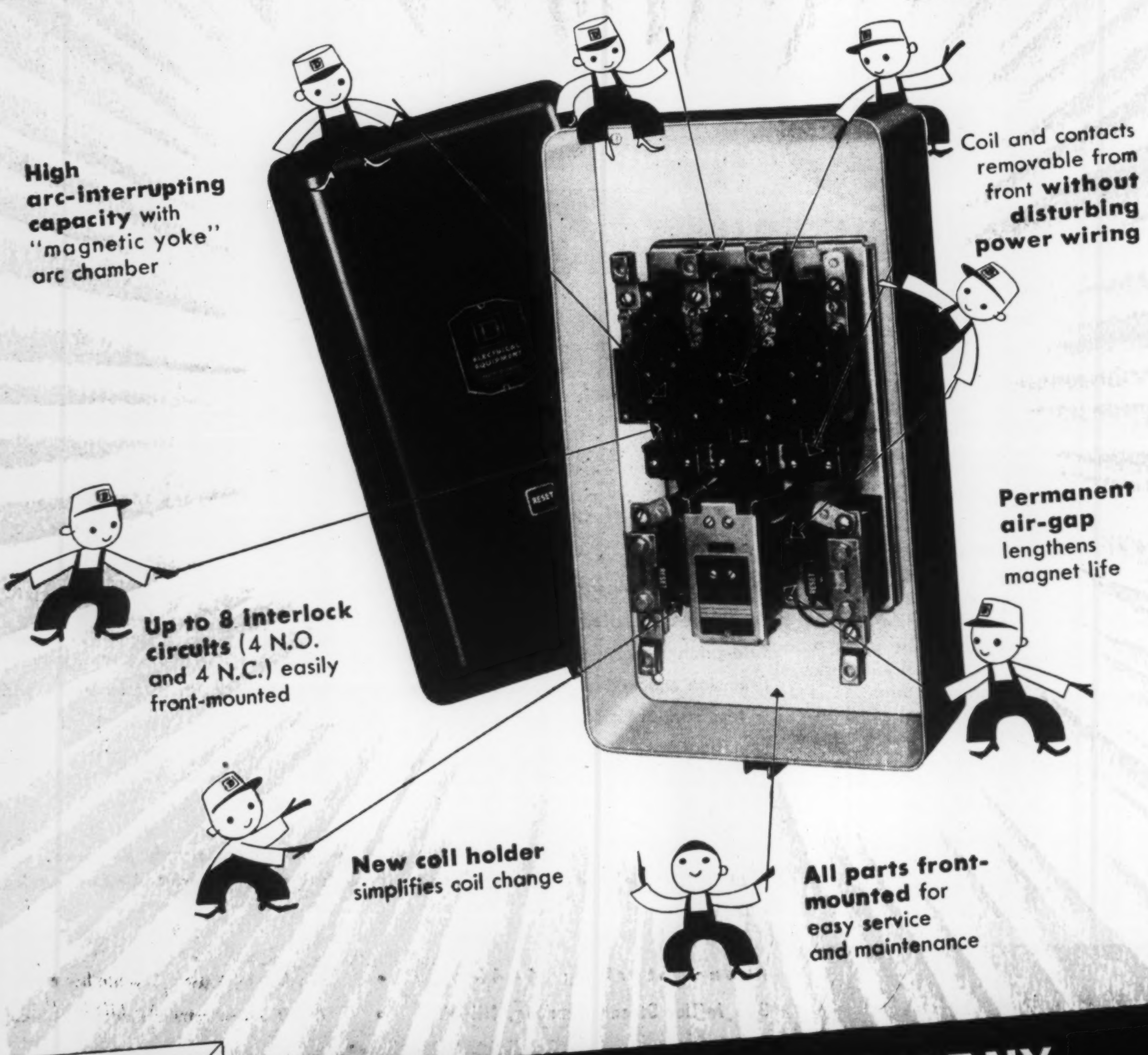
Feature-packed SIZE 4 STARTER

LATEST ADDITION

Balanced



"Hook-on" base design saves installation time and money

Special sintered metal contacts last longer

High arc-interrupting capacity with "magnetic yoke" arc chamber

Coil and contacts removable from front **without disturbing power wiring**

Permanent air-gap lengthens magnet life

Up to 8 interlock circuits (4 N.O. and 4 N.C.) easily front-mounted

New coil holder simplifies coil change

All parts front-mounted for easy service and maintenance

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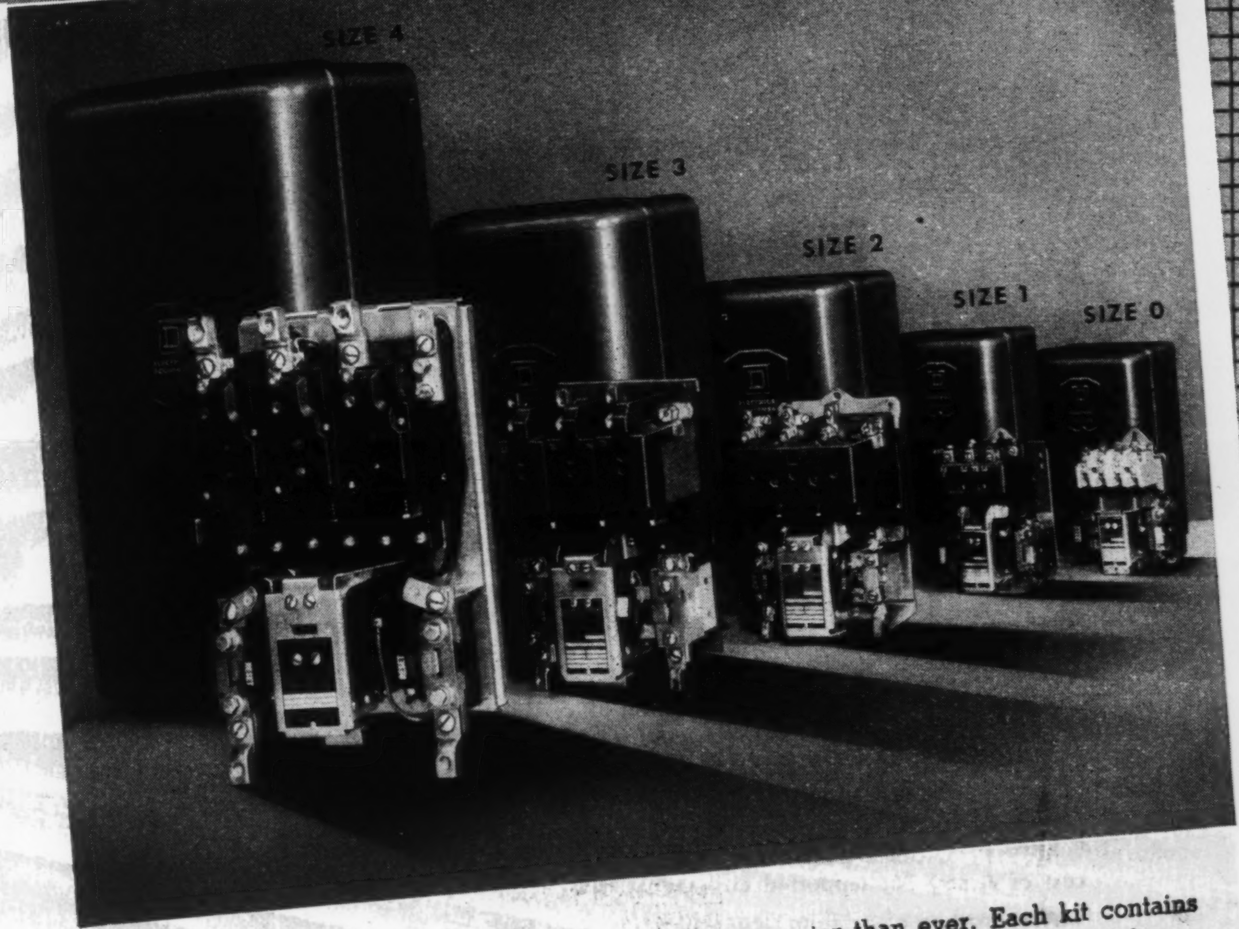
1903 · 50 YEARS OF DESIGN LEADERSHIP · 1953

TO SQUARE D's
Design MOTOR CONTROL



● The highest degree of accessibility, flexibility and compactness—with no sacrifice of performance and long life. That's Square D balanced design—and you'll find it in every size Square D starter.

"Off-the-Shelf" Parts Kits, another Square D convenience feature, make normal maintenance easier than ever. Each kit contains parts to replace all load contacts and finger springs. Electrical interlocks also available in kit form.

• • •

Write **for Bulletin 8536, Square D Company**
4041 North Richards St., Milwaukee 12, Wisconsin

ASK YOUR ELECTRICAL DISTRIBUTOR FOR SQUARE D PRODUCTS

U. S. Army Photograph

SPECIFICATIONS
MIL-A-10935-6-7

96 FOOT POUNDS IMPACT WITH NO FRACTURE

ALMAG 35

ALUMINUM ALLOY

withstands Extreme Test on 3/16" Wall Section

In order to pass the "Guillotine" test, bazooka barrels permanent-mold cast of Almag 35, supported on wedges, must withstand the impact without fracture of an 8 lb. steel ball dropped 12 feet.

Such performance is proof that Almag 35 excels all known Aluminum casting alloys for impact resistance strength.

A series of tests on *machined sections* of these production barrels showed Tensile Strength from 35,250 to 39,138 psi.; Yield Strength 19,488 to 20,373 psi.; and Elongation 12–15%.

Before you specify ANY alloy, ask for ALMAG recommendations.

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WILLIAM F. JOBBINS INCORPORATED

AURORA P. O. BOX 230 **ILLINOIS**

STOPS SHAKES...PUTS PURR-R-R IN POWER

PENFLEX
Flexineering

PENFLEX TUBING

TAMES POWER THROB . . . OPERATION COOLER

Get your copy of this folder on "Flexineering."

When two large diesels roar into action, there can be plenty of vibration transmitted to all points. This was true on one installation . . . engine vibration created a regular power throb.

The answer was found in a length of Penflex four wall interlocked air jacketed exhaust tubing on each exhaust. The flexibility of the tubing absorbed the vibration . . . put a purr in power. At the same time it achieved a circulation of air and efficient cooling action . . . prevented breakage due to thermal expansion.

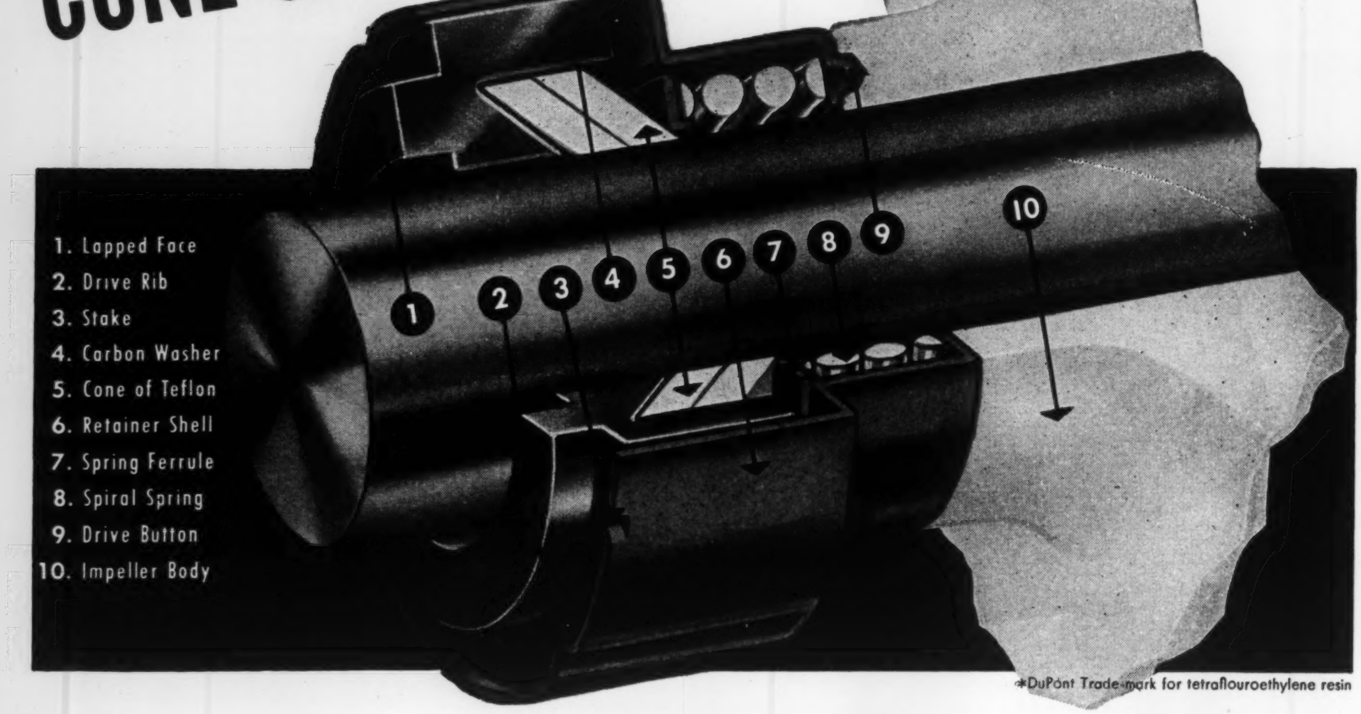
Whether your problem is vibration of exhaust lines or air lines . . . the transmission of liquids, volatiles, granular material or coarse abrasive products, Penflex engineers will be glad to work with you in the application of tubing from ⅛" I.D. on up. Penflex also manufactures barrel fillers, pneumatic rivet passers and a complete line of accessories and fittings.

Pennsylvania Flexible Metallic Tubing Company, Inc., 7239 Powers Lane, Phila. 42, Pa.
Branch Sales Offices: **Boston • New York • Chicago • Houston • Cleveland • Los Angeles**

PENFLEX

HEART OF INDUSTRY'S LIFE LINES

BRAND NEW CONE SEAL with TEFLON*



1. Lapped Face
2. Drive Rib
3. Stake
4. Carbon Washer
5. Cone of Teflon
6. Retainer Shell
7. Spring Ferrule
8. Spiral Spring
9. Drive Button
10. Impeller Body

*DuPont Trade-mark for tetraflouroethylene resin

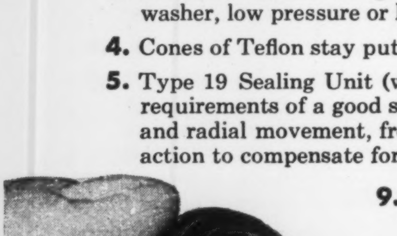
The All-Purpose Seal

For life-time performance in small pumps, hot water circulators and many other rotary shaft seal applications

Temp. −100° F. to +450° F. WATER-OILS-ACIDS PRESSURES 200 PSI

ADVANTAGES •• "JOHN CRANE" TYPE 19 CONE SEAL WITH TEFLON

1. Cones of Teflon will not deteriorate under −100° F. or +450° F.
2. Cones of Teflon are not attacked by any acid.
3. Cones of Teflon seal tight on shaft and in carbon washer, low pressure or high pressure.
4. Cones of Teflon stay put and have long life.
5. Type 19 Sealing Unit (with Teflon) has all the requirements of a good seal: positive drive, axial and radial movement, free sliding flexible spring action to compensate for wear of carbon washer, ease of application and replacement, long life, compactness.
6. Type 19 Sealing Unit (with Teflon) is a packaged seal, presently designed for small shafts ¼, ⅜, ½, ⅝, ¾" dia.
7. Type 19 Sealing Unit (with Teflon) is tooled for the high production field. It has a wide field of application.
8. Type 19 Sealing Unit (with Teflon) can be manufactured at an economical price.
9. Type 19 Sealing Unit (with Teflon) is manufactured in the "pressed-in" type where seal unit is held stationary.



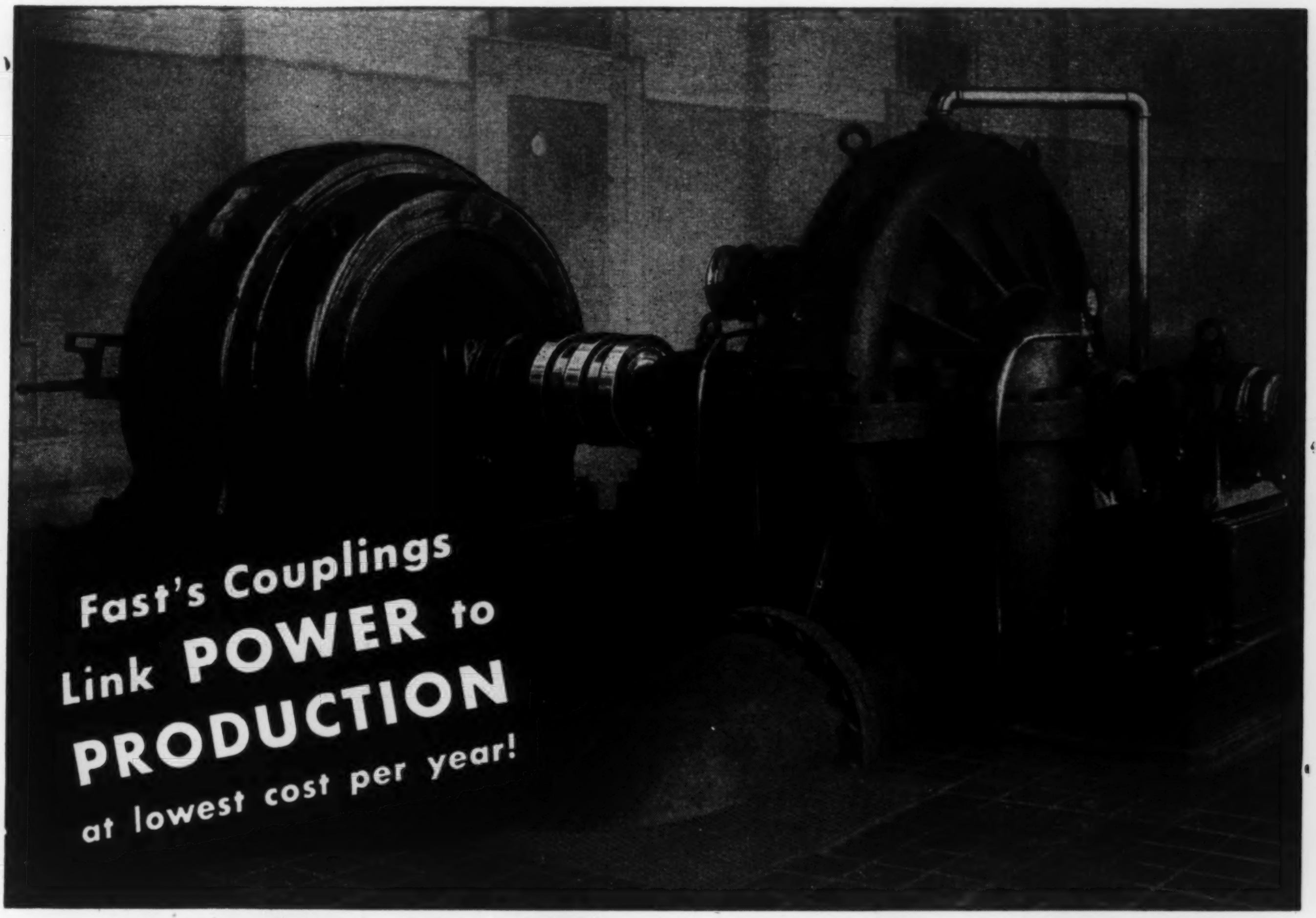
SPECIAL NOTE

Teflon is the answer to the automotive and aircraft engineer's specification for an extremely low and high temperature range. It is fast replacing rubber parts which have a tendency to harden, crack, soften, or otherwise fail.

In the early stages of any seal application we might be helpful. For instance—the metallurgy of a seal is important; you may have space limitations or you may have r.p.m. problems. These are only a few points. Drop us a line.

Crane Packing Company, Dept. MD 1825 Cuyler Avenue, Chicago 13, Illinois.

JOHN CRANE **CRANE PACKING COMPANY**



FAST'S Couplings usually outlast the equipment they connect!

ACTUAL cases on record show many Fast's Couplings are still in service after as much as 30 years of continuous operation! Time and time again, equipment has been replaced while the original Fast's Coupling remained on the job.

To you, these records of dependable, trouble-free service mean freedom from costly coupling failures when you specify Fast's. And they mean Fast's cost you far less to own and operate . . . because their cost can be amortized over long years of dependable performance.

For full details on how Fast's Couplings and Koppers Engineering Service can help you, write today for a free copy of our catalog to: KOPPERS COMPANY, INC., *Fast's Coupling Dept.,* 246 Scott St., Baltimore 3, Maryland.

Here's How FAST'S Save You Money

Free Service—Koppers free engineering service assures you the right coupling for the job.

Rugged Construction—Fast's still maintains its original design, without basic change or sacrifice in size or materials. Result: freedom from expensive coupling failures.

Lowest Cost per Year—Fast's Couplings usually outlast equipment they connect. Their cost may be spread over many years!

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FAST'S
THE ORIGINAL
GEAR-TYPE
Couplings

INDUSTRY'S STANDARD FOR 32 YEARS

KOPPERS COMPANY, INC., ***Fast's Coupling Dept.,***
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Gentlemen: *Send me Fast's Catalog which gives detailed descriptions, engineering drawings, capacity tables and photographs.*

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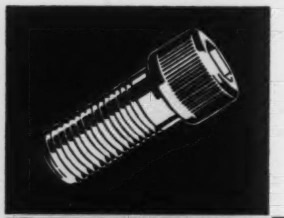
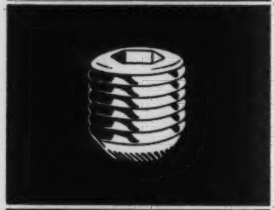
Time—because your local UNBRAKO distributor carries a complete stock of these close tolerance fasteners, and deliveries are prompt. Money—because it is possible in many cases to drill and tap fewer holes, use fewer screws, when you fasten assemblies with UNBRAKOS. Ask your local UNBRAKO distributor for a copy of UNBRAKO Standards or write SPS, Jenkintown 18, Pa.



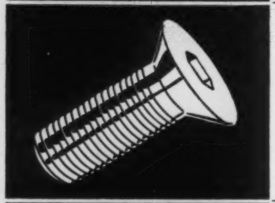
SOCKET HEAD CAP SCREWS

- Knurled head for sure finger grip and fast assembly
- Accurate hex socket for positive nonslip internal wrenching
- Heat treated alloy steel, controlled fillet and continuous grain flow for strength
- Fully formed threads—Class 3 fit
- Standard sizes—#4 to 1″



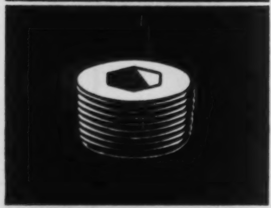
SELF-LOCKING SOCKET SET SCREWS

- Knurled cup point, for positive self-locking, won't work loose
- Accurate hex socket for nonslip internal wrenching
- Fully formed threads—Class 3 fit
- Heat treated alloy steel for strength
- Standard sizes—#4 to 1″



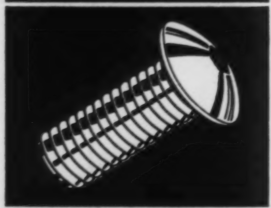
FLAT HEAD SOCKET CAP SCREWS

- Designed for flush head assembly of thin section materials
- Heat treated alloy steel for strength
- Uniform 82° angle under head for maximum contact
- Accurate hex socket for positive, nonslip internal wrenching
- Fully formed threads—Class 3 fit
- Standard sizes—#4 to ¾″



DRYSEAL-THREAD PRESSURE PLUGS

- Fully formed threads for positive sealing without compound
- Heat treated alloy steel for strength
- Continuous grain structure for stronger threads
- Controlled chamfer for faster starting of threads
- Accurate hex socket for nonslip internal wrenching
- Standard sizes—1/16″ to 1¼″ National Pipe Thread Fuel

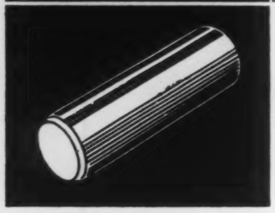


BUTTON HEAD SOCKET SCREWS

- Designed for applications where countersinking is not practicable
- Heat treated alloy steel for strength
- Low head height for streamlining designs
- Accurate hex socket for nonslip drive and freedom from marred or mutilated heads
- Fully formed threads—Class 3 fit
- Standard sizes—#8 through ⅝″, inclusive

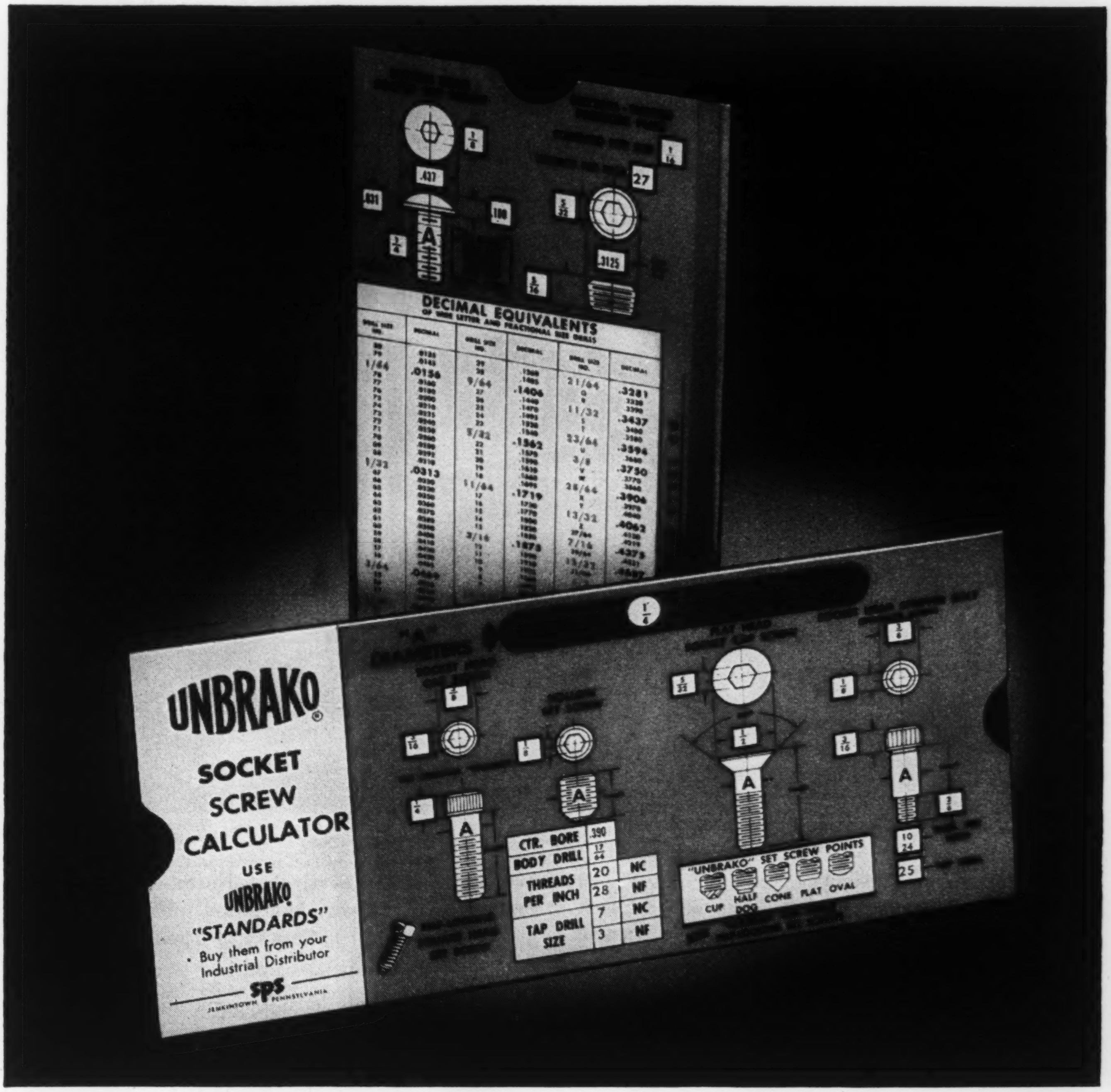
SHOULDER SCREWS OR STRIPPER BOLTS

- Heat treated alloy steel for strength
- Knurled head for sure finger grip and fast assembly
- Accurate hex socket for positive internal wrenching
- Shoulders held to unusually fine tolerances for close fit
- Threads and head concentric with the body for uniformly accurate assembly
- Finished threads close to the shoulder for holding power
- Fully formed threads—Class 3 fit
- Standard sizes—¼″ to ¾″



PRECISION GROUND DOWEL PINS

- Formed ends, with continuous grain flow, won't chip
- Surface hardness, Rockwell "C" Scale: 60-62
- Surface finish: 6 microinch maximum
- Core hardness, Rockwell "C" Scale: 50-54
- Average single shear strength: 150,000 psi
- Diameter tolerance: +0.0001″
- 2 standards—blue label pins .0002″ oversize to meet nominal press fit requirements; red label pins .001″ oversize for use as repair pins


DECIMAL EQUIVALENTS
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BODY DRILL 17/64
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TAP DRILL SIZE 7 NC 3 NF
"UNBRAKO" SET SCREW POINTS
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Our New UNBRAKO Socket Screw Calculator—YOURS FOR THE ASKING

This handy pocket-sized slide-rule type socket screw calculator gives diameters, lengths, socket dimensions, threads and drill sizes—in fact, everything you want to know when using UNBRAKO socket screw products. And it's free.

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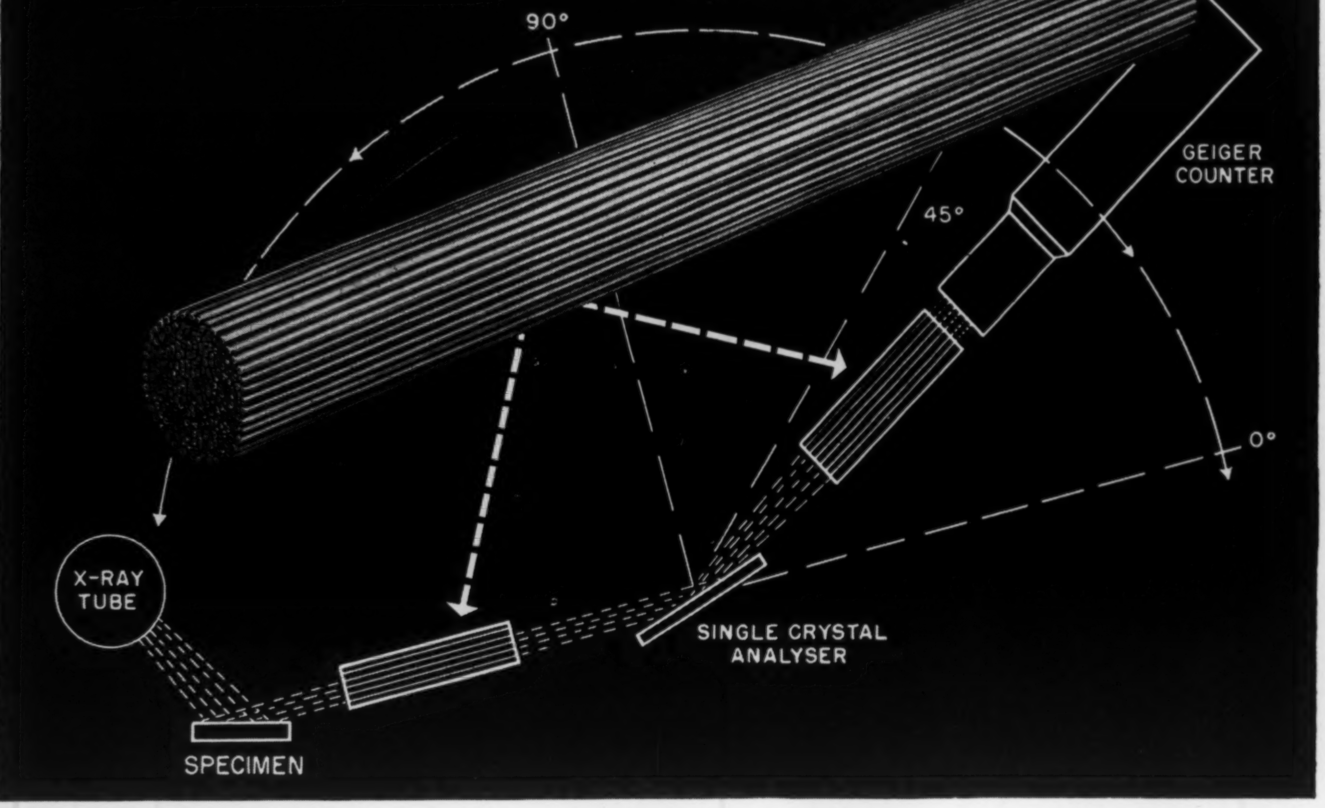
The cop who keeps x-ray traffic moving in parallel lanes



Fluorescence analysis is the new, fast way to find out which elements and how much of each are in alloys—without destroying the sample of the alloy.

This trick is accomplished by bombarding the alloy specimen with X-rays using a Fluorescence Analysis Unit produced by North American Philips, Inc. The x-radiations of each element bounce off the specimen only to be separated according to wavelength and measured.

As the x-radiations leave the specimen they shoot through bundles of fine tubes known as "collimators". The collimator acts as a kind of traffic cop, keeps the rays moving in parallel lanes, reduces divergence. This is an interesting job, and we're pleased that North American Philips chose Superior fine nickel tubing for it on the basis of its uniformity in diameter, wall thickness and finish.

Undoubtedly you have opportunities where tubing could be helpful—as a carrier, a weight-saving structural member, or as a shape that saves machining time. Look into the variety of forms, sizes, and analyses Superior produces to tight specifications. Take advantage of the experience and testing facilities that Superior brings to focus on your problem. Tell us the nature of your application and we'll send you information and a Data Memo by return mail. Superior Tube Company, 2010 Germantown Ave., Norristown, Pa.

Round and Shaped Tubing available in Carbon, Alloy, and Stainless Steels, Nickel Alloys, Beryllium Copper, Titanium and Zirconium.

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THE BIG NAME IN SMALL TUBING

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All analyses .010" to ⅝" O.D.
Certain analyses (.035" Max. wall) up to 1⅜" O.D.

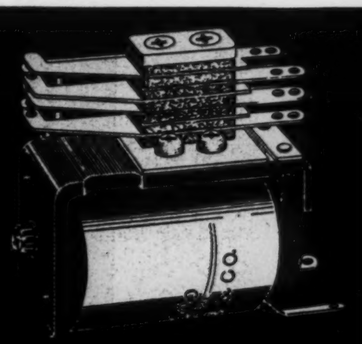
ONE OF THESE 4 CLARE RELAYS

will meet most exacting small-space requirements

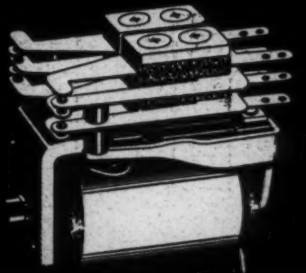
#A-8320
300 Ohms
C.P. CLARE & CO.
CHICAGO

CLARE TYPE K RELAY

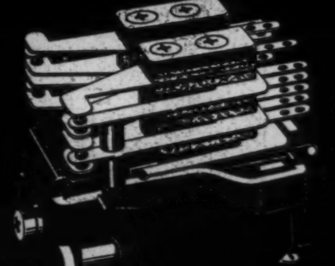
First small size, lightweight telephone type relay. Famous for operating speed and resistance to vibration.



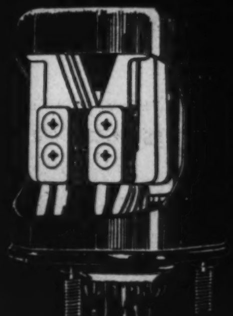
TYPE KX—Adds greater operating range and sensitivity with slightly longer coil.



TYPE R—Adds 120% greater sensitivity and 200% greater operating range than Type K.



TYPE N—Operates on less than 50 milliwatts with 10,000 Ohm coil, 1 form C contact and standard adjustment.



HERMETICALLY SEALED RELAYS

Type N Relay hermetically sealed in steeled container... a feature available with all Clare relays.

Clare pioneered the small-relay field with the Type K relay. Since that time it has been the mainstay of design engineers who must have a superior relay to operate in extremely small space.

The Clare Type K not only has the advantages of small size and light weight but it is capable of exceedingly fast operation, gives adequate contact pressure and is highly resistant to shock and vibration. Its long life and all-around dependability have enabled this relay to meet many complex engineering requirements.

In order to meet customers' specifications which the Type K would not quite fill, Clare engineers have developed three other small, light weight relays. All retain the basic operating and physical characteristics of the Type K. Two of them, the Type KX and the Type R, have the famous Clare reed armature suspension of special alloy. This has long been recognized as one of the subtler reasons for the superior performance of the Clare Type K relay.

The Type KX adds greater operating range and sensitivity by use of a slightly longer coil which can be safely wound to 8000 ohms resistance. The Type R adds still greater operating range and sensitivity by use of a coil not only longer but of greater diameter. The Type N relay is designed for operation on very low power. It employs a close-coupled magnetic circuit, generous use of magnetic iron and highly efficient coil design. This permits high sensitivity while retaining high contact pressure (minimum 30 grams) and adequate contact gap (minimum 0.0015″).

All these relays are available enclosed in hermetically sealed gas-filled containers which increase their life, reliability and usefulness under extreme conditions of altitude, temperature, moisture, fungi, dust and dirt.

Clare sales engineers are located near you. For complete information call the nearest Clare office or contact: C. P. Clare & Co., 4719 West Sunnyside Avenue, Chicago 30, Illinois. In Canada: Canadian Line Materials Ltd., Toronto 13. Cable Address: CLARELAY.

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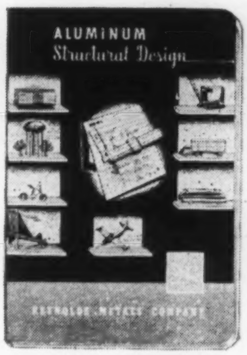
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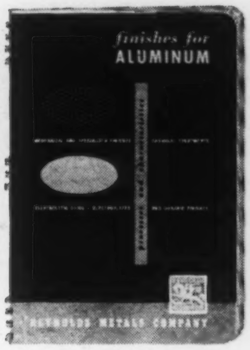
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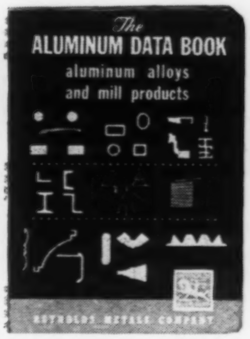
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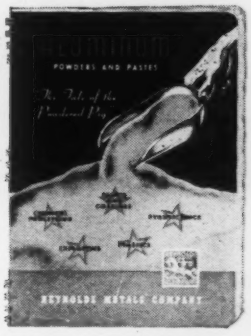
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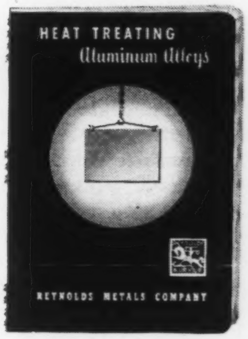
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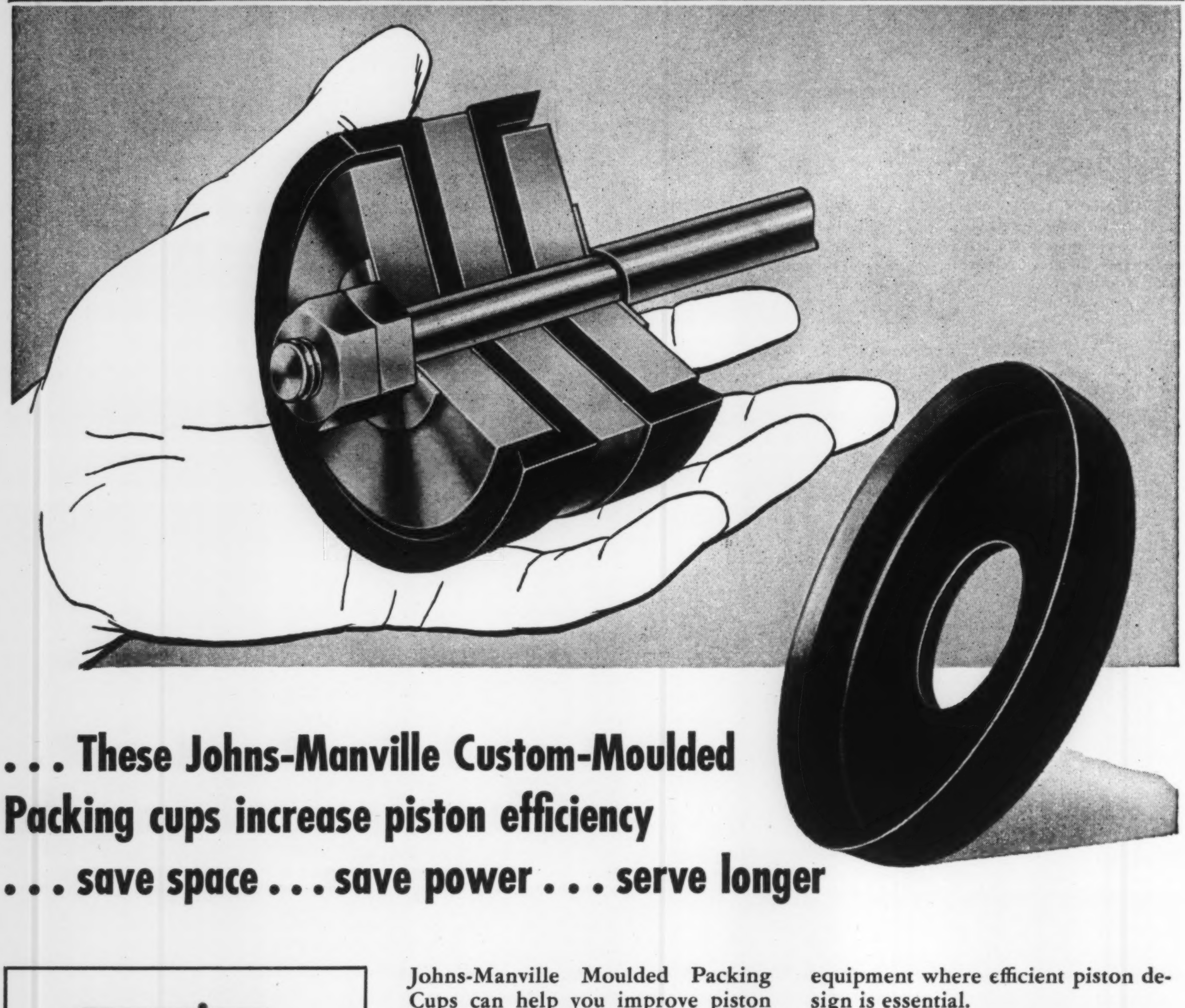
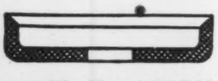
REYNOLDS ALUMINUM

MODERN DESIGN HAS ALUMINUM IN MIND

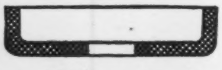
Looking for a more efficient piston design?



. . . These Johns-Manville Custom-Moulded Packing cups increase piston efficiency . . . save space . . . save power . . . serve longer



TYPE A . . . The Type "A" J-M Moulded Packing Cup is the "standard" for use on the pistons of pumps and on various hydraulic and pneumatic mechanisms. The lip forms a tight seal under discharge pressure, but relaxes on the reverse stroke, reducing friction and conserving power.



TYPE B . . . This type of cup is essentially the same as Type A, except that the leading edge of the lip is square instead of beveled. This construction provides greater strength where the lip may be exposed to distortion or excessive wear due to openings in cylinder walls.

Johns-Manville Moulded Packing Cups can help you improve piston designs. They provide a highly efficient seal . . . improve equipment performance . . . lower operating and maintenance costs. These custom-made packings are extensively used on all types of slow moving pistons and rams operating under high or low pressures and temperatures.

Johns-Manville Moulded Packing Cups may be used on practically all air or hydraulic-operated cylinders. For instance, those which are in such equipment as reciprocating pumps, hydraulic jacks and presses, pneumatic chucks, governors, lift trucks, grease guns, valves, drilling and boring machinery . . . or on any other equipment where efficient piston design is essential.

You have your choice of a number of styles and compositions of these precision-moulded cups to meet temperatures and pressures encountered in hydraulically operated equipment. Types "A" and "B," shown here, are most widely used on inside-packed pistons with the outside edge or lip contacting the cylinder wall or liner. Other types are available, however, for other services.

If you would like more information on these or other types of Johns-Manville Custom-Made Piston Packings, get in touch with your Johns-Manville Packings Distributor, or write Johns-Manville, Box 60, New York 16, N. Y.

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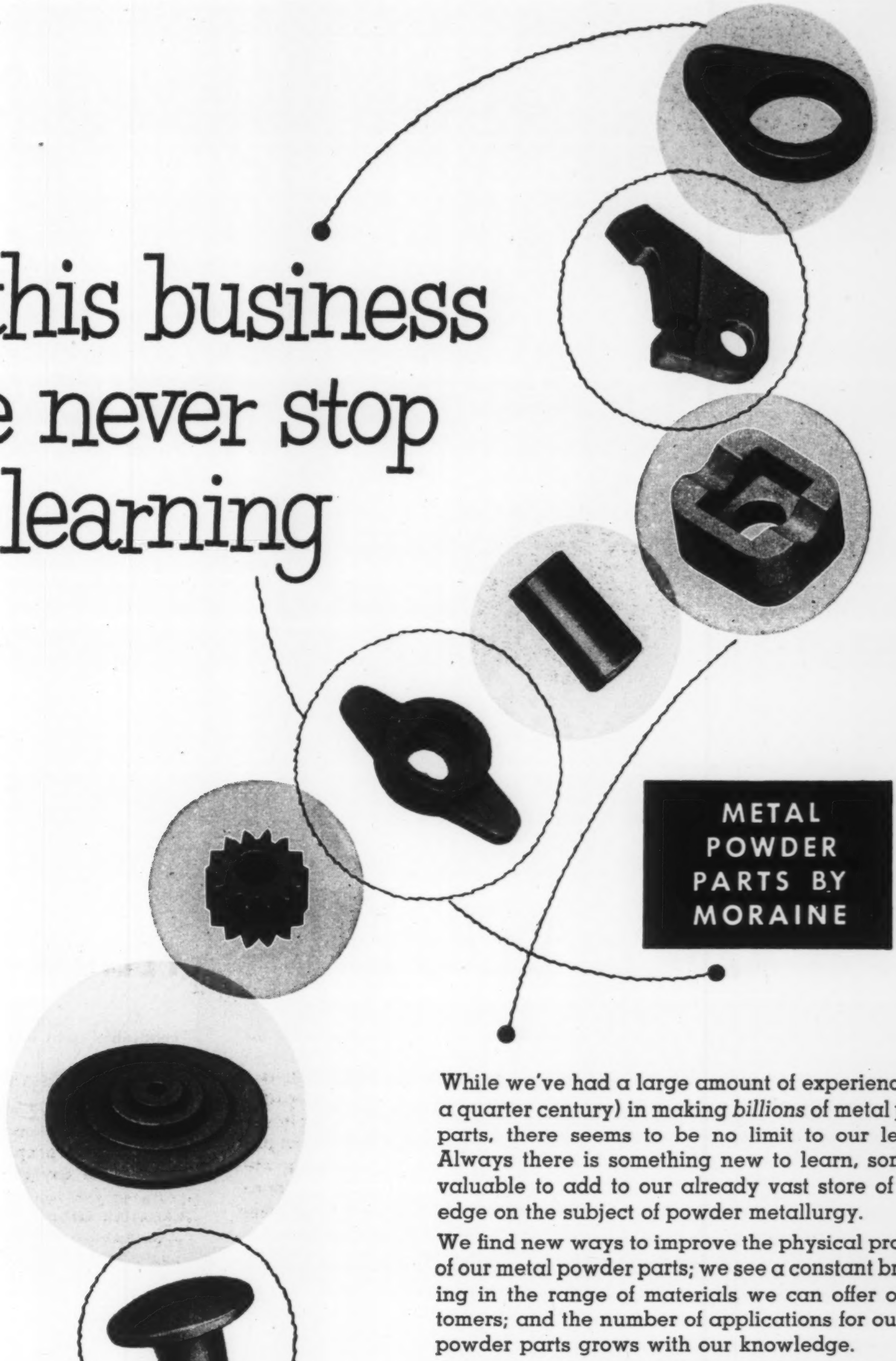
Johns-Manville PACKINGS & GASKETS

in this business we never stop learning



METAL POWDER PARTS BY MORAINE

While we've had a large amount of experience (over a quarter century) in making *billions* of metal powder parts, there seems to be no limit to our learning. Always there is something new to learn, something valuable to add to our already vast store of knowledge on the subject of powder metallurgy.

We find new ways to improve the physical properties of our metal powder parts; we see a constant broadening in the range of materials we can offer our customers; and the number of applications for our metal powder parts grows with our knowledge.

We're proud of the position we've reached in the field of powder metallurgy . . . but no prouder than we are of the way our products are able to serve industry by improving performance while cutting costs.

m

moraine products

DIVISION OF GENERAL MOTORS CORPORATION, DAYTON, OHIO

Cans that won't leak require gibs that don't wear

THEY'RE MADE OF BERYLCO BERYLLIUM COPPER

When you discard a tin can, you may not think you're throwing away a precision device, but you are. All parts of a can must be accurately formed to within one ten-thousandth inch, otherwise leakage and spoilage will result.

The flat and bevel gibs shown here are used on a bodymaker producing 12 and 6 oz. spray cans. Twenty-six dies, each guided by similar Berylco gibs, turn out 100 can bodies per minute. Tolerances are so critical that gib wear of less than .001'' can cause trouble. Production stoppages pile up headaches, and thousands of cans can be ruined through corrosion.

Gibs machined from Berylco #25 bar stock have now been employed for the "SPRA-TAINER" bodymaker twice as long as any previously used material, and there have been no shutdowns. The superior wear resistance of Berylco is due not so much to its heat-treatable feature—work-hardening alone is sufficient—as to its dense, less porous structure, which reduces friction and makes lubrication less critical.*

Wear resistance is only one of the many desirable engineering qualities of Berylco beryllium copper. Its unique combination of such properties as strength, conductivity, elasticity and fatigue resistance has enabled designers to convert difficult or "impossible" jobs into standard production items.

As the world's largest producers, we will be glad to help you include beryllium copper in your plans for the future. For sample material or engineering assistance, call or write any of the offices below.

VALUABLE ENGINEERING INFORMATION on Berylco beryllium copper is contained in a series of technical bulletins, published monthly. To receive your copy regularly, write on your business letterhead.

TOMORROW'S PRODUCTS ARE PLANNED TODAY—WITH BERYLCO BERYLLIUM COPPER

** Data supplied by Crown Can Co. (Div. C. C. & S. Co.), Phila., Pa.*

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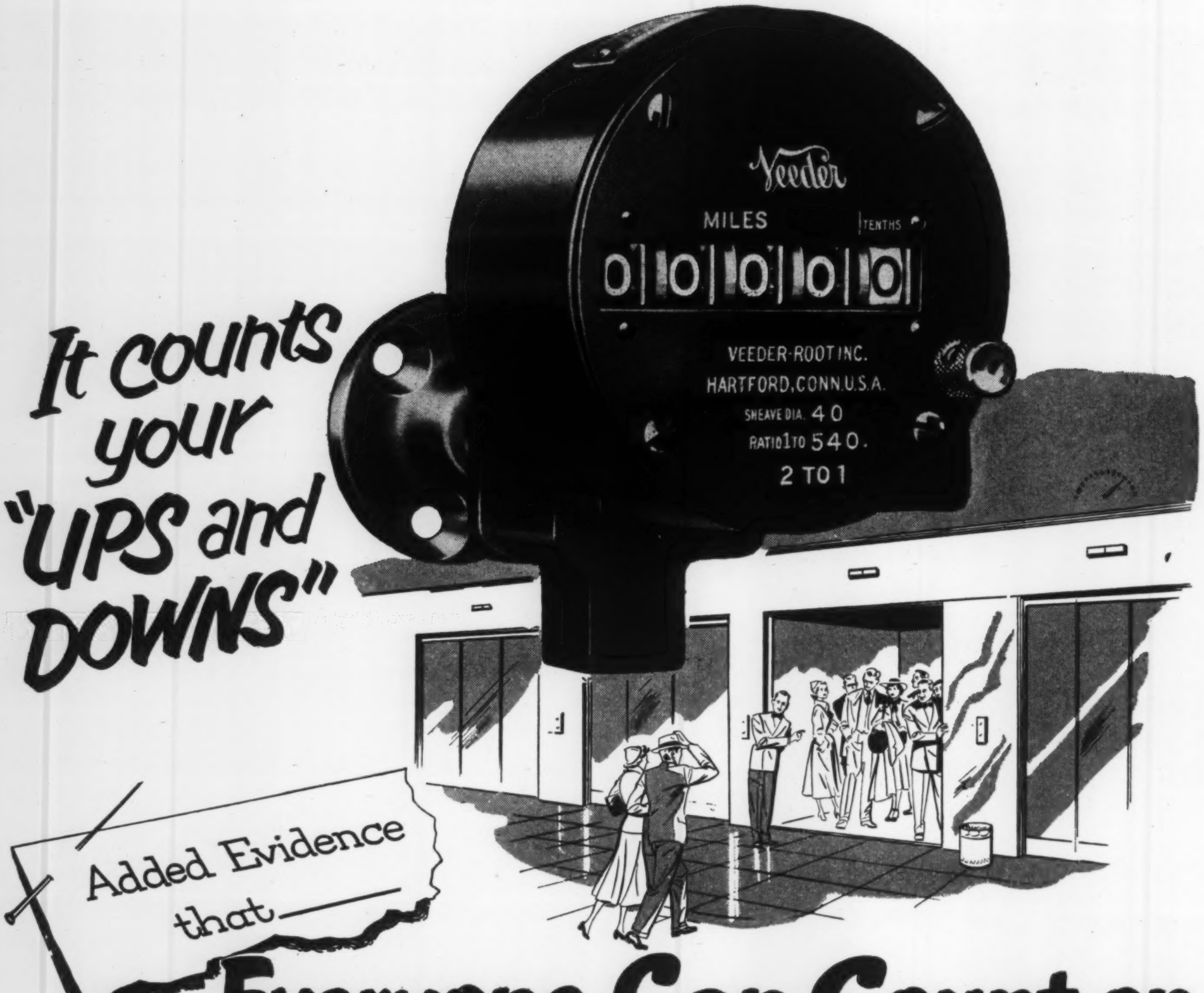
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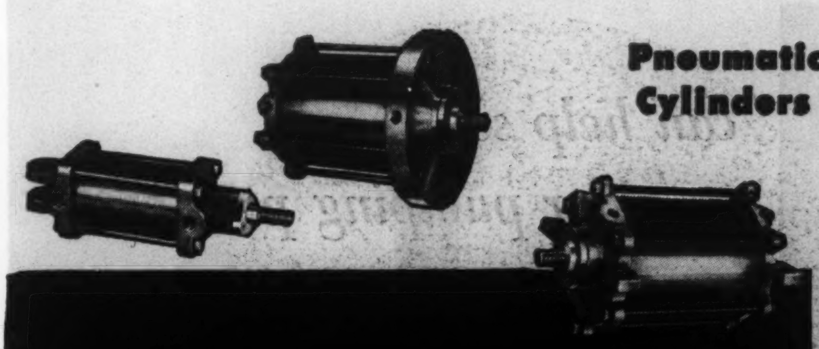
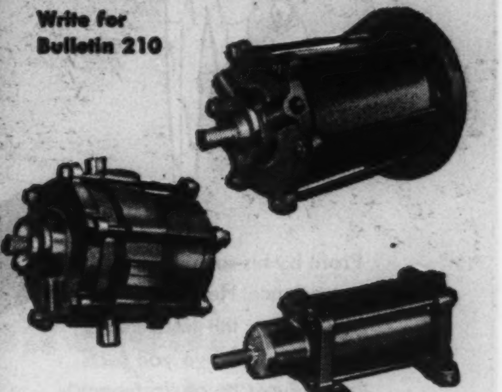


Pneumatic Cylinders

Really complete, the Hannifin line of pneumatic cylinders is made with two types of pistons . . . bores from 1" to 16" . . . six standard mountings. Really standard, these cylinders are tooled to tolerances that assure accurate mounting to make assembly to your machines easier. Really built, each cylinder is "TRU-BORED" and honed, piston rods are ground and polished, interchangeable end caps, heavy duty tie rods . . . rugged, yet precision construction throughout!

Write for Bulletin 210



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NEW! REVOLUTIONARY HANNIFIN

P-M Pilot-Master Valves

Piston-operated poppet design. Exclusive replaceable cartridge for easier maintenance. Speeds to 600 cycles per minute. Pressure from 15 to 150 p.s.i. Integral, solenoid-controlled pilot heads or a choice of 10 separate pilot valves for remote control.

- Fewer Valves to Stock
- Fewer Parts to Stock
- Maximum Interchangeability
- No Springs in Main Valve

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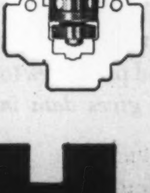
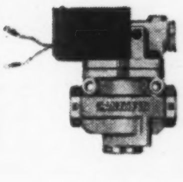
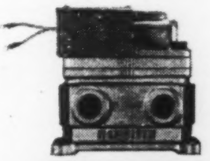
EXCLUSIVE REPLACEABLE CARTRIDGE



2 and 3-Way Valves.

Same valve operates 2-way or 3-way, normally open or normally closed. 3/8" to 1¼" I.P.S.



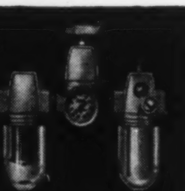


4-Way Valves.

Two 3-way valves mounted in compact, common body. Two piston poppets. Two cartridges. 3/8", ½", ¾" I.P.S.

AIR WARDEN

Air filters, pressure regulators and lubricators to protect air operated equipment. Bulletin 1010B.



Disc Type Air Control Valves

Designed for smooth, positive and accurate control of air-operated equipment. Bronze discs lapped to perfect seal with seats. Packless design. For hand, foot or electrical operation. Sizes: 1/8" to 1¼" I.P.S.

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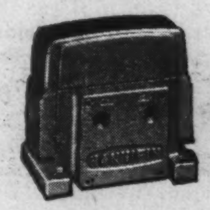
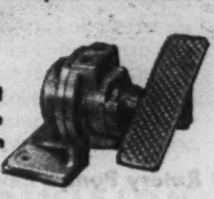


Hannifin "Directair" electrically controlled air-operated disc valve



Foot-operated treadle valve (Also spring return and rotary types)

Standard hand control valve (Single or duplex)

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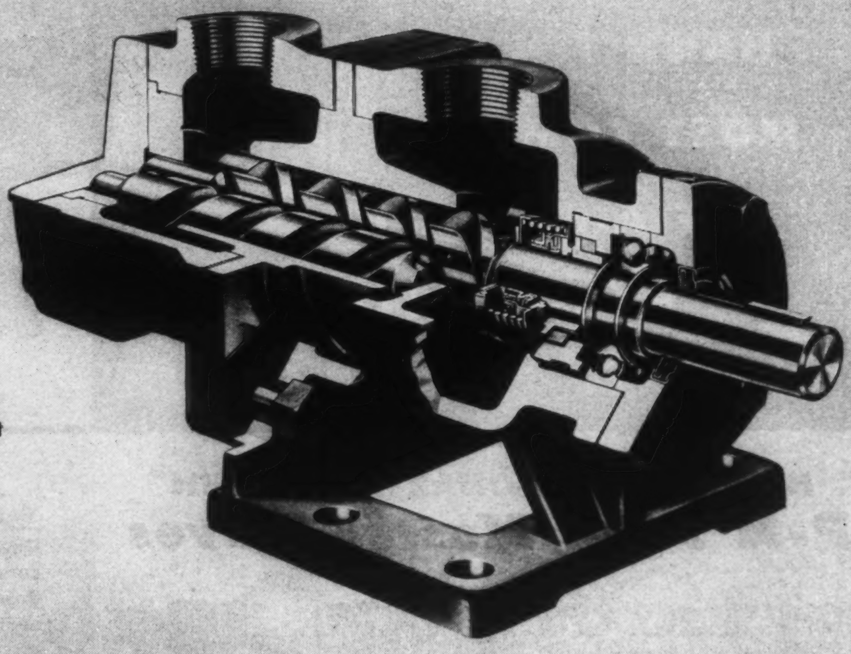
FIELD
REPRESENTATIVE

can help solve your pumping problems

Profit by his sound, versatile experience. He can aid you in selecting the IMO Pump you need . . . give you facts and figures on performance . . . bring valuable judgment to bear on your specific fluid handling application.



For example, De Laval-IMO Series A313B Pump handles light or viscous fluids in hydraulic systems, rotary and steam atomizing oil burners, lubrication, governing systems and similar services. Use it for capacities to 80 gpm, pressures to 275 psi and intermittent pressures to 325 psi.

IMO Rotary Pumps have only 3 moving parts. There is nothing to get out of order, nothing to adjust. IMO Pumps are also easy to install. They can be direct-connected to electric motors, turbines or other high speed drivers, without reduction gearing, belts or chains.

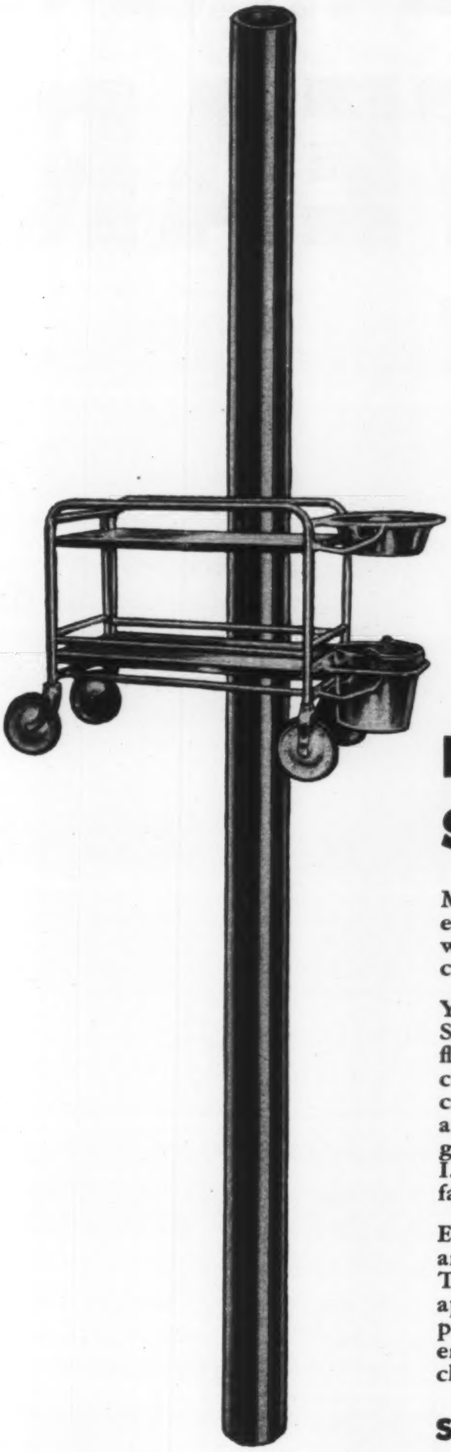
Rotors are in hydraulic and dynamic balance. That means pulsation free operation—no churning, no pocketing, no intermittent strokes. The natural smooth rolling action of IMO rotors eliminates noise, vibration and hydraulic whine.

Models can be furnished for almost any fluid handling problem in capacities to 750 gpm and pressures to 1,500 psig. *Ask for Bulletin LG-A which gives data in chart form on the wide range IMO line.*

DE LAVAL *IMO Pumps*

DE LAVAL STEAM TURBINE COMPANY
858 Nottingham Way, Trenton 2, N. J.

DL187



Here's an idea: Stainless Steel Tubing

Maybe your product has to be attractive. Or sanitary, easy to clean. Or strong, and long lasting. Maybe you want high resistance to heat and corrosion. Easy fabrication. Low end cost.

You'll find all these advantages in ELECTRUNITE Enduro Stainless Steel Tubing and Pipe. Formed from clean, flat-rolled steel. Uniform wall thickness . . . uniform concentricity . . . uniform quality, inside and out. You can bend them. You can join them by fusion or resistance welding. Or solder them. Or braze them. You can grind, polish or buff tubing to a mirror-like finish . . . I.D., O.D., or both. Or Republic will do it for you. We'll fabricate it, too.

ELECTRUNITE Enduro Stainless Steel Tubing and Pipe are available in a variety of chromium-nickel analyses. Tubing also in type 430. The type that fits your particular application . . . properly used . . . can pay its way in better performance and lower maintenance costs. Republic engineers and metallurgists will be glad to help you choose it. For design data and specifications, write to:

STEEL AND TUBES DIVISION
REPUBLIC STEEL CORPORATION
217 EAST 131st STREET • CLEVELAND 8, OHIO

REPUBLIC STEEL ®

Republic

ELECTRUNITE

STAINLESS STEEL TUBING AND PIPE

PRODUCED BY THE MAKERS OF ELECTRUNITE — THE ORIGINAL ELECTRIC WELDED BOILER TUBE

Get on the right track to

BEAT WEAR

▲ Nordberg Track Jack in operation. Machine consists basically of two hydraulic rams, each capable of lifting 24,000 lbs. Ampco Metal is used in the moving parts of the hydraulic rams because of its excellent resistance to wear.

Nordberg Mfg. Co.

Milwaukee, Wisconsin

The Product: Nordberg Hydraulic Power Jack used to lift rails and ties from roadbed during reballasting or resurfacing.

The Problem: To keep wear in the moving parts of the hydraulic rams to a minimum. Because the piston and gland act as guides, close tolerances must be maintained. In addition, the hydraulic ram utilizes pressures of 3000 psi and, although the piston has "0" rings with back-up washers, extremely close fits must be maintained between piston and gland to hold this pressure.

The Solution: AMPCO METAL for both piston and gland.

The Results: Thanks to the ability of Ampco Metal to resist wear, proper clearances and tolerances are maintained. The result — dependable performance, greater output.

IT'S PRODUCTION-WISE TO AMPCO-IZE

CMH REX-FLEX *Stainless Steel* Hose...

Proved on the Cummins Diesel *Special* — 1952 Indianapolis Pole Position Winner!

28
CUMMINS DIESEL
Special

The three sections of REX-FLEX hose circled at the right passed one of the most severe tests to which flexible metal hose can be put. They successfully withstood the heat and vibration of the exhaust line of the Cummins Diesel Special as it captured the coveted pole position at the 1952 Indianapolis 500 mile race with a speed of 138.010 mph. for the 10 mile qualifying run.

Performance like this is your best assurance that CMH REX-FLEX will do the job whenever liquids or gases must be conveyed under conditions of vibration, flexation, misalignment, expansion and contraction, corrosion or temperature extremes. CMH REX-FLEX is available in sizes from 5/16″ to 6″ I.D. braid covered or unbraided. It is suitable for burst pressures to 24,000 psi, temperatures to 1600° F. Write for descriptive literature or see the Flexonics catalog in Sweet's File for Product Designers.

CHICAGO METAL HOSE Division

Flexonics *Corporation* 1339 South Third Avenue, Maywood, Illinois

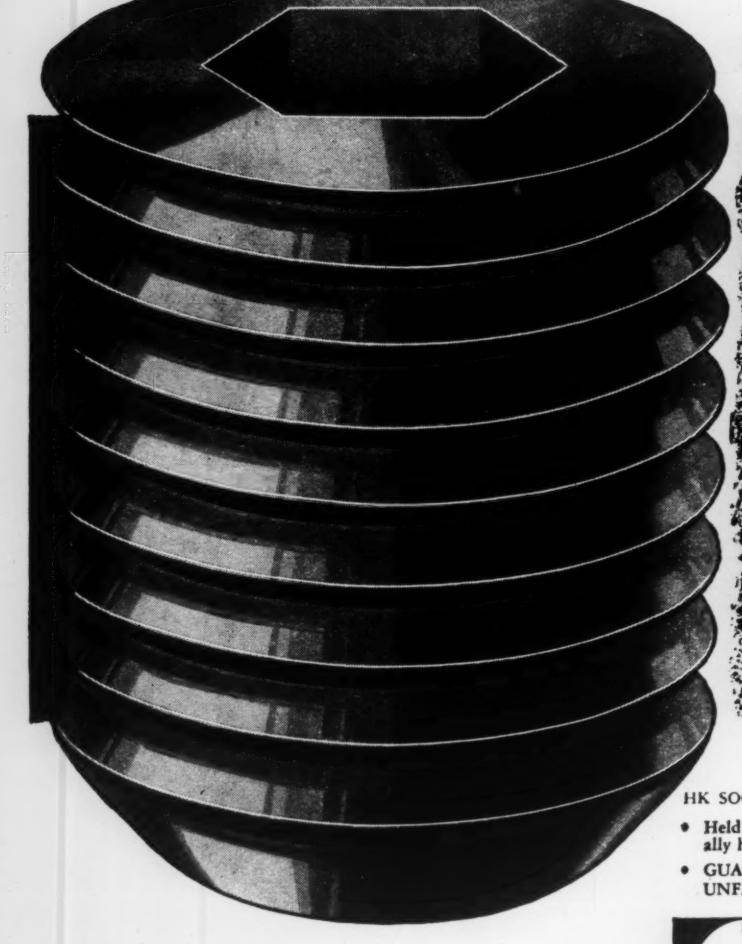
In Canada: Flexonics Corporation of Canada, Ltd., Brampton, Ontario

Flexon identifies CMH products that have served industry for over 50 years.

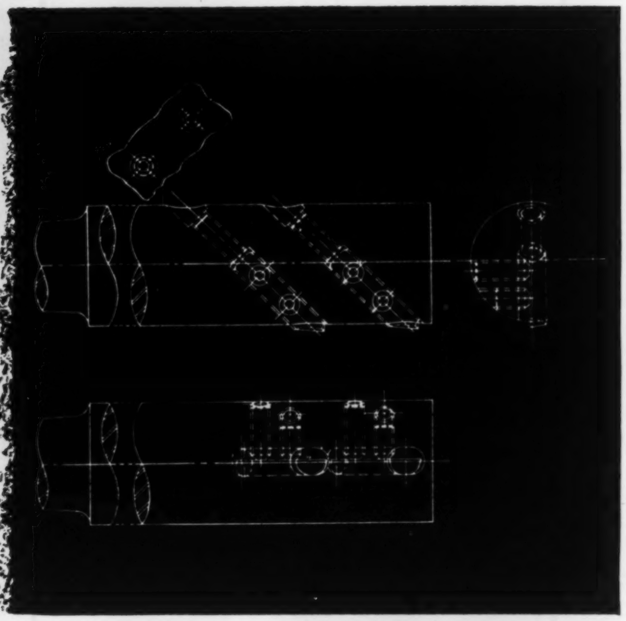
CMH

Flexible metal hose *Expansion joints* *Aircraft components* *Metallic bellows*

SPECIFY
HOLO-KROME . . . the BETTER
fastening method.



SET SCREWS



HK SOCKET SCREWS ARE:

- Held to Class 3 Thread Fit . . . Individually hand inspected.
- GUARANTEED TO GIVE UNFAILING PERFORMANCE.

Saves WEIGHT

Saves MATERIAL

Saves TIME

Saves SPACE

HK SOCKET SCREWS ARE:

- Made of special analysis alloy steel by a Holo-Krome patented process and heat treated to develop the utmost in physical properties.
- Quality controlled in Holo-Krome's own Physical and Chemical laboratories.

CALL YOUR H·K
AUTHORIZED
INDUSTRIAL DISTRIBUTOR TODAY

D8

HOLO-KROME
Completely Cold Forged
SOCKET SCREWS
THE HOLO-KROME SCREW CORP., HARTFORD 10, CONN. U. S. A.

LOGAN FLUID POWER • DURABLE, DEPENDABLE SINCE 1916

Igussu Falls, Brazil . . . as seen from the Argentine side. Drops 237 feet. Water swirls down over an arc 2½ miles wide resulting in a breathtaking color display of every conceivable pastel hue.

LOGAN *AIR-DRAULIC®* **FEED-CONTROLLED** **CYLINDERS**

POWER MOVEMENTS IN ANY DIRECTION — NO POWER UNIT REQUIRED

COMBINES

the fast-acting, economical low pressure operation of

AIR

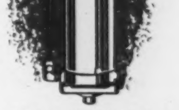
with the smooth, uniform controlled regulation of

OIL

5 ***STANDARD MOUNTING TYPES***

Standard bores from 3" to 8". Any stroke to 5 feet. For air pressures to 150 p.s.i.

Furnished for controlled feed with rapid return in either direction, or with controlled feed in both directions. Skip-feed movement can also be provided.



Air-Draulic Cylinder with Flange Mounting at Rod End

LOGAN MANUFACTURES 6,975 STANDARD CATALOGED ITEMS

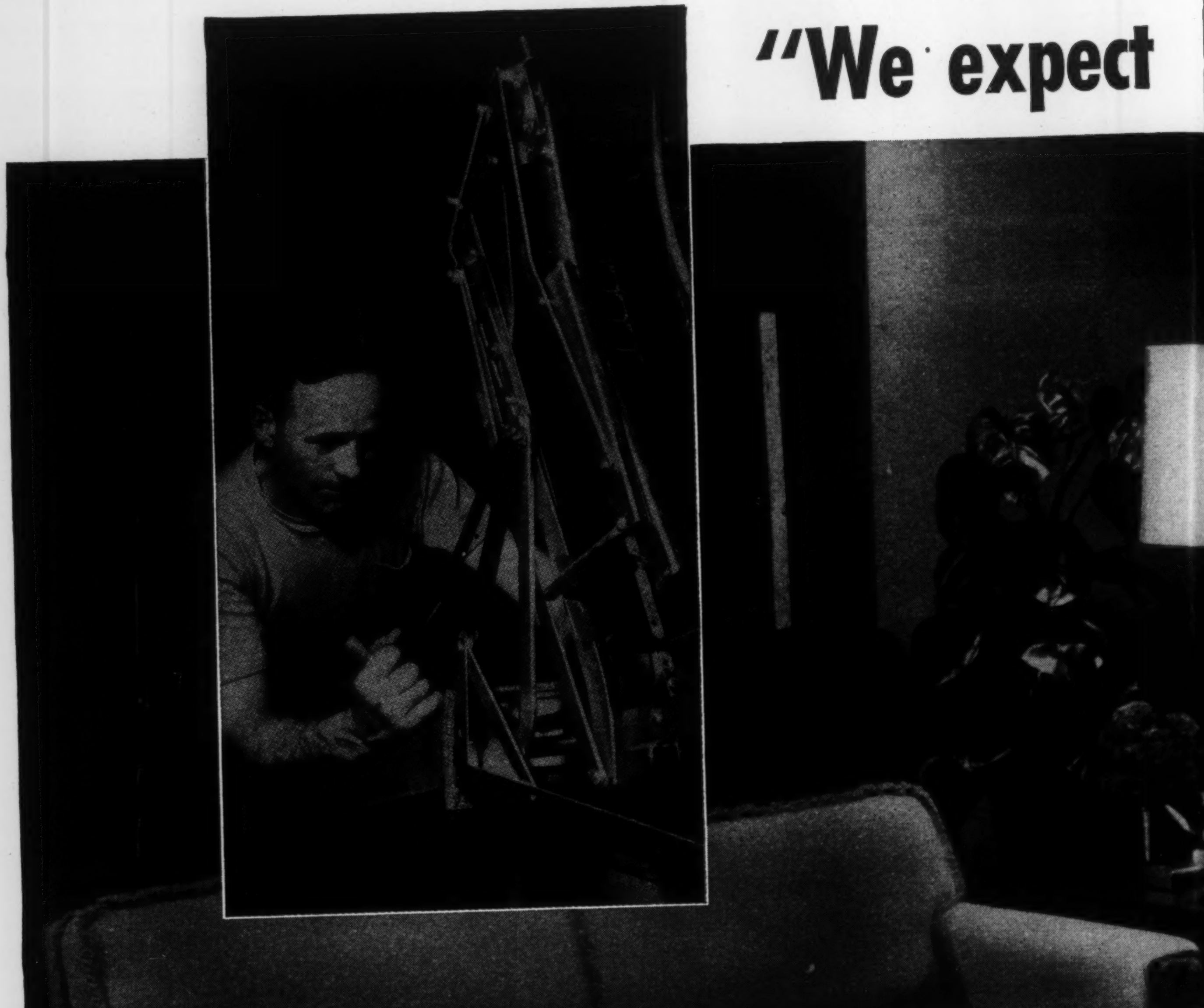
FREE CATALOG ON REQUEST

AIR CONTROL VALVES, Cat. 100-4 • AIR CHUCKS, Cat. 70-1 • AIR CYLINDERS, Cat. 100-1 • AIR-DRAULIC CYLINDERS, Cat. 100-3
AIR and HYDRAULIC PRESSES, Cat. 51 • COLLET GRIP TUBE FITTINGS, Cat. 200-5 • HYDRAULIC CONTROL VALVES, Cat. 200-4
HYDRAULIC CYLINDERS, Cats. 200-2; 200-3 • HYDRAULIC POWER UNITS, Cat. 200-1 • SURE-FLOW COOLANT PUMPS, Cat. 62

SAVES TIME
Logan
AIR AND HYDRAULIC EQUIPMENT
EFFORT • MOTION

LOGANSPORT MACHINE CO., INC., 811 CENTER AVE., LOGANSPORT, IND.

"We expect



20 years of service or more from these American Quality Springs"

...says SIMMONS COMPANY

World's largest producer of sleeping equipment

EVERY housewife in America knows that the name *Simmons* is an ironclad guarantee of quality when it appears on a mattress or sofa.

If you visited any of the 7 Simmons factories, you'd know why. Simmons has built an unparalleled reputation by *insisting* on fine workmanship and highest quality component parts.

Look at the famous Hide-A-Bed shown here. You don't have to yank and pull to open it into a comfortable bed. It glides open easily on 6 counter-balance American Quality Springs. Each of these 9-inch springs must withstand a stretch to 15 inches. In a 20-year period, these 6 helical springs are stretched to the limit 14,600 times.

We produce these springs for Simmons using a high-grade oil-tempered wire. As a result, the finished springs meet very close load tolerances, and they are consistently straight.

If you need a typewriter spring, an automobile axle spring, or a spring to support a giant locomotive, American Steel & Wire will help you design it. Then we'll produce it—any size, any grade of steel, any shape, any finish. You'll get all this at a price you never thought possible.

Just call your nearest American Steel & Wire district office.

AMERICAN STEEL & WIRE DIVISION, UNITED STATES STEEL CORPORATION, GENERAL OFFICES: CLEVELAND, OHIO
COLUMBIA-GENEVA STEEL DIVISION, SAN FRANCISCO, PACIFIC COAST DISTRIBUTORS
TENNESSEE COAL & IRON DIVISION, FAIRFIELD, ALA., SOUTHERN DISTRIBUTORS • UNITED STATES STEEL EXPORT COMPANY, NEW YORK

USS

U·S·S American Quality Springs

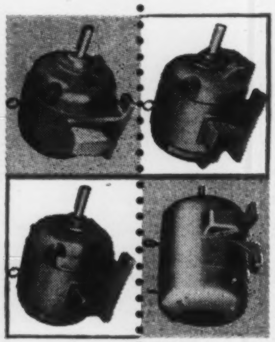
UNITED STATES STEEL

ELECTRO

Extra DYNAMIC

Dependable industrial motors

1 TO 250 HORSEPOWER (N.E.M.A. STANDARDS)



One-piece cast iron frames.

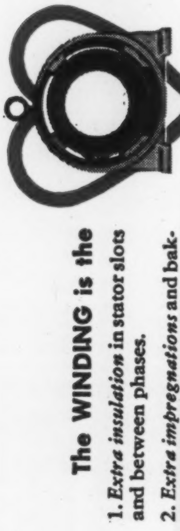
Extra large "free-flo" air channels.

Permanently aligned cast iron brackets.

Liberal size grease lubricated bearings.

Also a complete line of Direct Current motors and generators

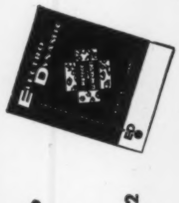
ELECTRO DYNAMIC
DIVISION OF GENERAL DYNAMICS CORPORATION
BAYONNE, NEW JERSEY



The WINDING is the HEART of the motor

1. *Extra insulation* in stator slots and between phases.
2. *Extra impregnations* and bakings of the wound stator.
3. *Extra high-frequency testing* of insulation between turns.
4. *Extra care* in fitting coils into stator.

QUALITY SINCE 1880

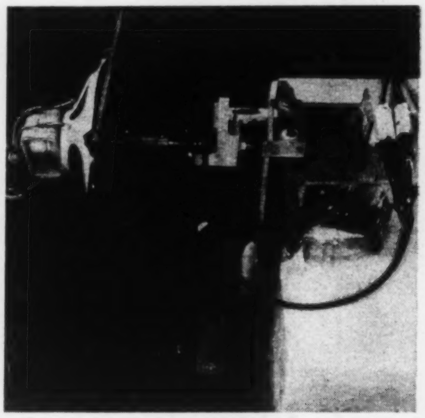


WRITE TODAY FOR NEW ILLUSTRATED CATALOGUE NO. 662

(*Continued from Page* 260)

of the resonant frequency of the beams. This makes it possible to cover a range of 10 to 250 cps with only 3 sets of beams. Changing from one set to another requires only ten minutes.

In operation, the plates are clamped to a steel frame at their lower ends and to a block at their free ends. The loudspeaker drives the free ends through a thin plastic rod glued to the speaker cone. A conventional audio oscillator and 50-watt amplifier drive the speaker.



Because of the resonance of the mechanical system, only a small amount of power is needed to obtain suitable vibration amplitude. Electrical wave-form is not critical as the resonant system acts as a mechnical filter to give pure sinusoidal wave form. Displacements from 5 to 5000 microinches have been satisfactorily measured with an autocollimator, and an inexpensive microscope with a built-in reticle has given good accuracy with larger displacement.

Build First Press For New Drawing Method

Deep drawing metal parts by the new Hidraw method is accomplished on a press built by Hydraulic Press Manufacturing Co. A combination cushion and rubber pad process, the new method was developed and perfected by Consolidated Vultee Aircraft Corp. In co-operation with Convair and other aircraft manufacturers, Hydraulic Press engineers added de-

best for the **BIG** ones too

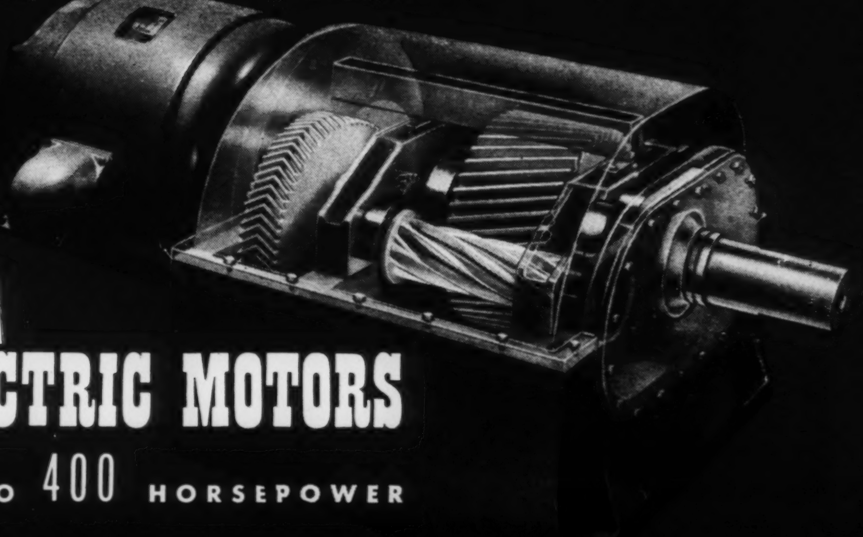
When you use a power drive which is an assembly of motors, pulleys and belts, chains and sprockets, gearing, speed reducers, etc., you waste time and money in purchasing, handling and assembling these various units into the final drive.

Master power drives designed as complete units with component parts matching size for size and rating for rating offer you considerable saving in space and money . . . especially in the larger sized units.

So don't put up with "make-shift" assemblies when you can select from Master's broad line, standard units which easily combine to give you the RIGHT horsepower, the RIGHT shaft speed, the RIGHT features in one compact unit that you can use RIGHT where you want it.

Use the RIGHT power drive to increase saleability of your motor driven products . . . improve the economy, safety, and productivity of your plant equipment. That's the horsesense way to use horsepower.

THE MASTER ELECTRIC COMPANY • DAYTON 1, OHIO



MASTER ELECTRIC MOTORS

1/8 TO 400 HORSEPOWER

New Bullard vertical chucking grinder gets high precision, handles heavy loads with table on TIMKEN® bearings

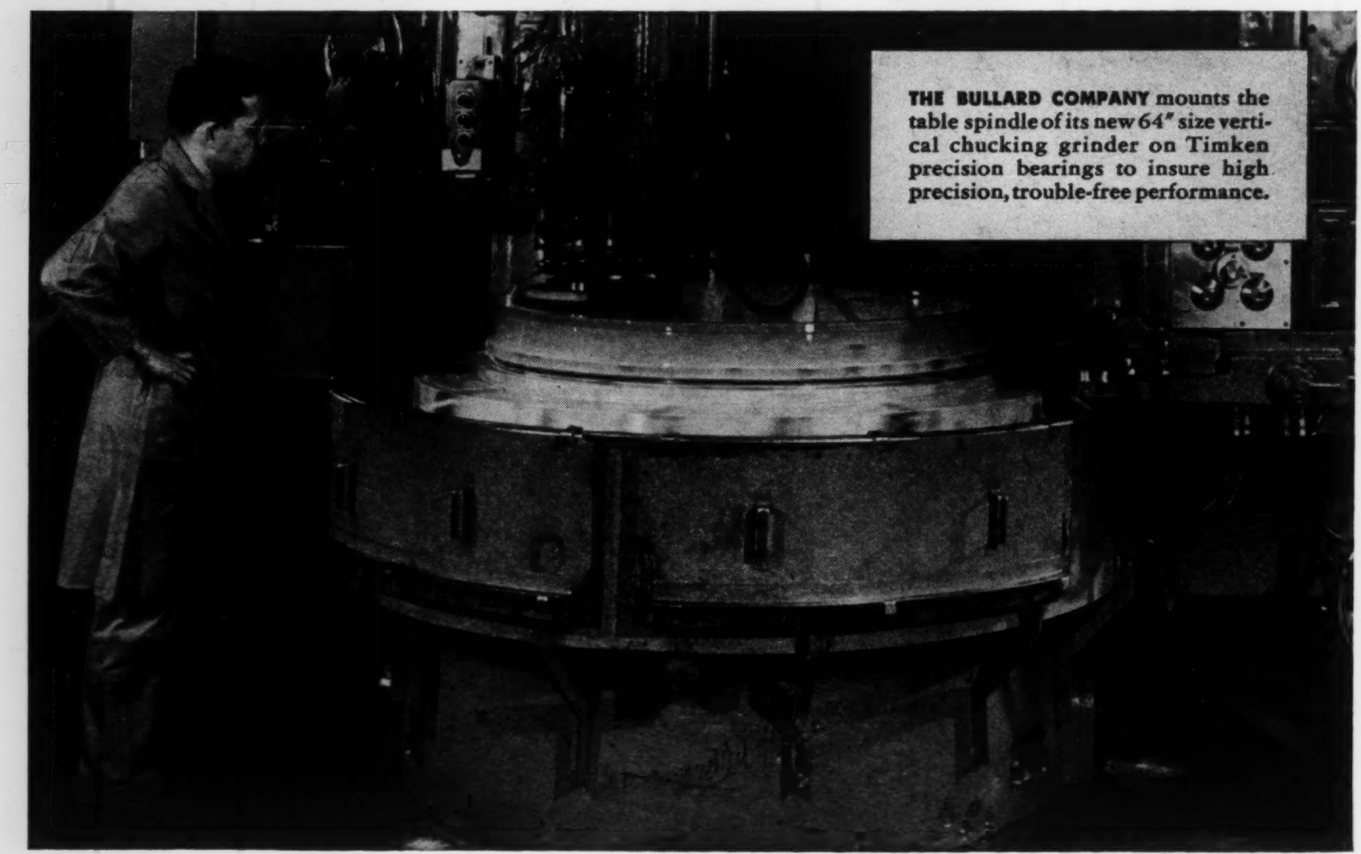
To insure the high precision needed in finishing cups and cones for large-size roll neck bearings, Bullard mounted the table spindle of a new 64″ size vertical chucking grinder on Timken® tapered roller precision bearings. Timken bearings are also used in many other vital spots.

Line contact between their rollers and races gives Timken bearings extra load-carrying capacity. Their tapered construction takes radial and thrust loads in *any* combination. Result: Shafts are held in rigid alignment. Shaft deflection and end-play are minimized. Gears mesh smoothly. Spindle precision is assured.

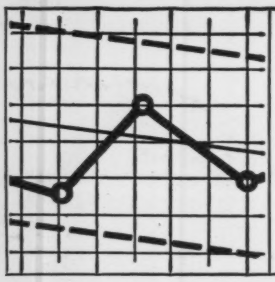
True rolling motion and an incredibly smooth surface finish make Timken bearings practically friction-free. Maintenance and lubrication time and costs are cut to a minimum.

Precision manufactured, made of Timken fine alloy steel and engineered for the job, Timken bearings normally last the life of the machine. Specify Timken bearings in the machinery you build or buy. Look for the trade-mark "Timken" stamped on every bearing. The Timken Roller Bearing Company, Canton 6, Ohio. Canadian plant: St. Thomas, Ontario. Cable address: "TIMROSCO".

This symbol on a product means its bearings are the best.



THE BULLARD COMPANY mounts the table spindle of its new 64″ size vertical chucking grinder on Timken precision bearings to insure high precision, trouble-free performance.



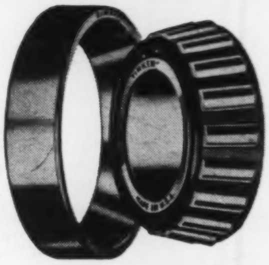
STATISTICAL QUALITY CONTROL

To insure uniform high quality and closer tolerances, the Timken Company uses statistical quality control. With it, tolerance deviations are plotted graphically. It's one of industry's newest, most scientific methods of improving product uniformity.

TIMKEN

TRADE-MARK REG. U. S. PAT. OFF.

TAPERED ROLLER BEARINGS



NOT JUST A BALL NOT JUST A ROLLER THE TIMKEN TAPERED ROLLER BEARING TAKES RADIAL AND THRUST LOADS OR ANY COMBINATION